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Study of Radiation Patterns Using Modified Design of Yagi-Uda Antenna

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Abstract: Antenna is very important in wireless communication system. Among the most prevalent antennas, Yagi-Uda antenna is widely used. To improve the antenna gain and directivity, design of antenna is always important. In this paper, the Yagi Uda antenna is modified by adding two more reflectors instead of single and the gain, directivity & radiation pattern were studied. This antenna is designed to give better gain in one particular direction as well as somewhat reduced gain in other directions. The direction of "reduced gain" and gain at particular direction are not controllable in Yagi Uda. This paper provides a design which modifies radiation pattern of Yagi as per user requirement. The experiment is carried out at 157 MHz and all readings are taken for vertical polarization, with the help of Radio Communication Monitor.

Keywords: Wireless communication, Yagi-Uda, Communication Service Monitor, Vertical polarization.

1 Introduction

Antennas have numerous advantages such as they can be suitably used for wide range of applications such as wireless communications, satellite communications, pattern combining and antenna arrays. Antenna is an electrical device which forms an interface between free-space radiations and transmitter or receiver. The choice of an antenna depends on various factors such as gain, impedance, bandwidth, frequency of operation, Side Lobe Level (SLL), etc.

Initially, the Yagi-Uda antenna was used for domestic application that is for receiving signals for televisions but recently they also found there application in wireless system [1-5]. Yagi-Uda antenna is a widely used antenna design at VHF and UHF due to its high forward gain capability (typically, greater than 10dB), low cost and ease of construction [6-8,18].

In this paper, special emphasis is given in designing of three reflector Yagi-Uda antenna and the modified radiation pattern and related parameters have been studied.

2 Antenna Design Parameters

In this paper, proposed antenna is modified form of simple Yagi Uda antenna. In this design instead of single reflector, two additional reflectors (total number of reflectors are three) are used. The said antenna is designed with following set of parameters,

- Type:- Yagi-Uda antenna with additional two reflectors
- Input :- FM modulated signal of 157 MHz, with stability of 2 PPM (Parts Per Millions)
- Frequency stability
- Antenna polarization:- Vertical
- Signal measured:- From Communication Service Monitor.
- Coaxial cable:- RG 58Au with N type connector.
- Radio used:- Motorola GP339 handheld trans receiver.

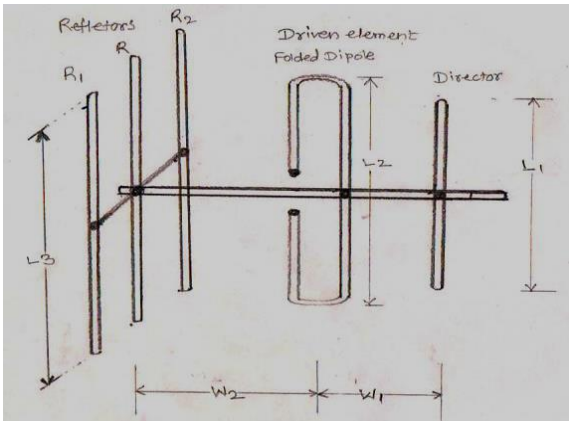

Fig. 1 Multi reflector antenna

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The design of proposed multi reflector antenna is shown in Figure-1. It is designed at frequency 157 MHz. The signal is transmitted from Motorola make type GP339 VHF handheld trans receiver. The signal is collected at the proposed antenna and feed to communication service monitor [Make& Type- IFR-2945B]. [9-13]
The same setup is carried out for 3 element Yagi, ground plane (GP) and results were compared. The same antenna is tested at field and lab results are confirmed.

Table 1: Details of various parameters for designing

1	Frequency Used	*f*	157 MHz
2	Length of Director	L1	77 cms
3	Length of Folded dipole	L2	87 cms
4	Length Reflectors	L3	95 cms
5	Separation between L1 & L2	W1	24 cms
6	Separation between L2 & L3	W2	29 cms
7	Horizontal Separation between Reflectors, R and R1, R and R2	θ	30°& 60°

The arrangement for installing additional reflectors with respect to folded dipole is as shown in Figure 2. FD indicates folded dipole, D indicates director and R1. R, R2 indicates reflectors. The readings are taken by changing angle θ i.e. for θ = 30° and θ = 60°.

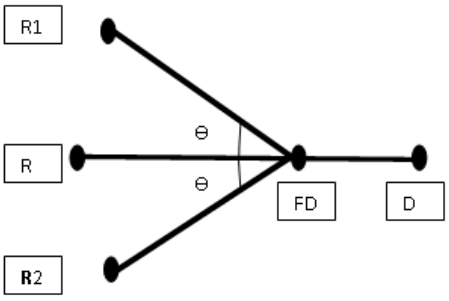

Fig. 2 Arrangement of reflectors.

3 Results and Discussion

In the literature review, it is seen that in case of simple 3 elements Yagi antenna the radiation pattern is directional and focused maximum in the direction of director element. The back lobe has very very low gain due to physical dimension of reflector and its distance from folded dipole or radiating element.
The modified set up of Yagi Uda consists of three reflectors and a director which give the radiation pattern as shown in figure 3. This pattern clearly indicates, as the angle between Reflector R, R_1 and R, R_2 changes, the radiation pattern also modifies and give considerable gain in the required direction. It is possible to increase gain in particular direction by adjusting position of additional reflectors and amount of gain, half power bandwidth (HPBW) and forward to backward ratio (f/b) can be controlled by changing angle θ. [14-17].

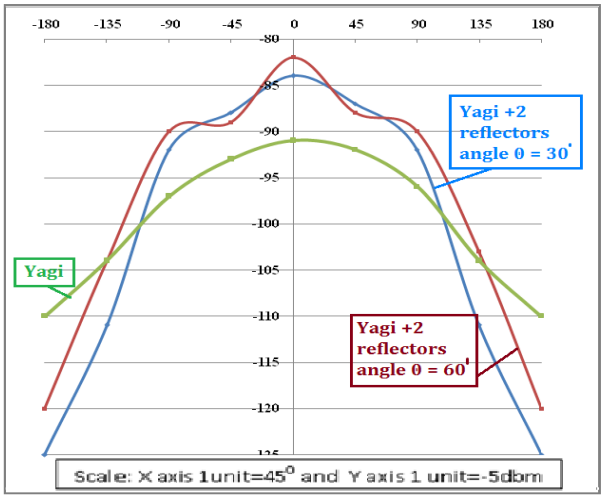

Fig. 3 Radiation patterns for Yagi with single reflector and multi reflector at different angles.

The results of receiving field strength are collected by changing position of transmitter. The same experiment is carried out by changing the said aerial with ground plane and Yagi and results were compared. Then the position of reflector is changed by angle of 30°, 60°progressively and results were tabulated (Table 2).

Table 2: Variation in different parameters of Yagi- Uda antenna with three reflectors.

Sr. no.	Parameter	Three Element Yagi-Uda	Yagi-uda with additional two reflectors at 30^0 angle	Yagi-uda with additional two reflectors at 60^0 angle
1	**Gain**	6 dbi	12 dbi	14 dbi
2	**Directivity**	7.37 dbi	10.875 dbi	15.75 dbi
3	**HPBW**	123°	83°	60°
4	**F/B ratio**	19dbm	35dbm	41dbm

It is found that as reflector position is changed, from θ = 30° to θ = 60° the radiation pattern shifts, forward gain increases and beam width reduces. The reduction in beam width is proportional to the angle of reflectors. More the angle, less is the 3db beam width and greater is the directive gain. [14,16]

Table 2 shows the result of Yagi-Uda antenna with additional two reflectors. It shows approximate 6 to 8 db forward gain improvement compared to 3 element Yagi, .i.e. up to 12db to 14db compared to isotropic antenna. This structure modifies back lobe & gives gain in backward direction as well as the direction of our requirement, by controlling reflector angle.

Table 3: Variation in power of Yagi-Uda antenna for different aerials.

Sr. No.	Type of aerial	Forward power in watts	Reflected power in watts
1	GP	21	0.1
2	3 Element Yagi	21	0.1
3	3 Element Yagi with additional two reflectors	21	0.1

Table 3 shows variation in forward power and reflected power of Yagi Uda antenna with multiple reflectors. The power is checked by using Bird's through line wattmeter. Hence we can conclude that antenna impedance does not considerably changes compared to simple Yagi Uda antenna.

4 Conclusion

In this paper, three reflector Yagi-Uda antenna have been designed successfully. It is observed that the directivity and gain of antenna increases & can be controlled by changing position of reflectors, which is very useful for wireless communication and other applications.

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