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Design of High Gain Yagi-Uda Antenna in VHF Band

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Abstract **- A Yagi-Uda antenna of five elements is designed with use of surface reflector instead of wired reflector to improve gain of antenna at 160MHz frequency. Antenna has hollow assembly therefore it is portable for easy transportation. More gain with HPBW of 90^0 is achieved with simulation in 4NEC2. VSWR is achieved 1.3 which is measured on Network Analyzer and simulated in 4NEC2. The results are also verified with the help of Ansoft HFSS software.**

Index Terms**— curved surface reflector, high gain, boom, bush, wire antenna.**

I. INTRODUCTION

Since Yagi-Uda antenna was invented in the 1920's [1], it has drawn a considerable amount of attentions. As we increase the number of directors the gain of Yagi-Uda antenna increases but consequently the bulkiness also increases and HPBW results in decreasing value. It also affects on front to back ratio with increasing back lobe [2]. If we tilt the element by some angle alpha, the HPBW increases which decreases the gain of antenna [3]. Thus to maintain front to back ratio with respect to less number of directors, we have used curved surface reflector so as to improve antenna gain without increasing number of directors. Use of curved surface reflector reduces the back lobe in desired manner and does not affect HPBW. Curved surface reflector has advantage over wired reflector because it shows higher gain in comparison with wired reflector.

To achieve long distance communication at 160 MHz frequency we can use various types of antenna such as horn, helical, spiral, conical etc, but the performance of Yagi-Uda antenna in VHF band is better than any other antenna with compact size and easy manufacturing. As we improve gain of Yagi-Uda antenna it will reduce the number of repeaters in communication region. As frequency is 160 MHz corresponding wavelength for this frequency will be 1.875 meter which will result in large size antenna, so we implemented some mechanical ideas to reduce size of antenna. We made antenna portable that can be assembled and dissembled at site of use.

For maximum power transfer from transmitter to antenna impedance matching is important. In half wave dipole, input resistance and reactance increases along with length of dipole. So we have chosen length of dipole (0.48 λ) such that antenna has zero imaginary component in the impedance of antenna so that antenna became resonant. We preferred dipole antenna over folded dipole, even though we get better results in folded dipole antenna (280 Ohm). Because in folded dipole antenna, it is difficult to match impedance.

Size reduction of antenna can be achieved with different techniques according to type of antenna, for example, In Yagi-Uda antenna, we have implemented thread lock system in each elements of antenna i.e. directors, reflectors and dipole . We have made press and fit slots at considerable distance on boom of antenna which results in easy access for installation of antenna. This antenna is specially designed for Maharashtra Police Wireless Communication System.

II. ANTENNA DESIGN AND SIMULATION

A. Design:

Conventional Yagi-Uda antenna consists of mainly three elements i.e. directors, reflectors and dipole where directors and reflectors are parasitic element.

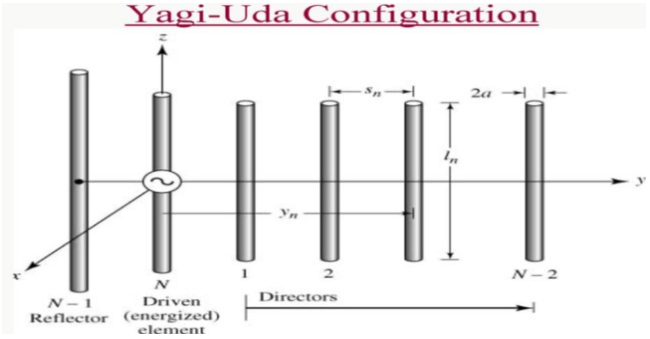

Fig.1 conventional Yagi-Uda antenna

As shown in figure 1, dimensions are as follows
Dipole=0.48λ Director1=0.45λ Director2=0.40λ
Director3=0.35λ Reflector=0.55λ Boom=20*20mm

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This antenna is designed to operate at 160 MHz which is Government Allocated Police Wireless Communication Band. For this frequency, wavelength is 1.875 meters. For this VHF band frequency, Yagi-Uda is the best fitted antenna to be used. This antenna consists of five elements in which three are director elements. Feed box is connected with driven element to feed the signal from cable RG-58 (50 Ohm). This cable is connected using BNC connector. Feed box is isolated from environmental resistance.

We have used curved reflector in addition to the conventional Yagi-Uda antenna. Instead of using conventional wired reflector, we implemented a curved surface reflector which shows us drastic change in functional characteristics of conventional Yagi-Uda antenna. The structure of curved surface reflector is designed in such a way that its surface area is narrow at bush and gradually increases away from boom. Bush is nothing but the medium to connect different elements and the boom of antenna.

B. Simulation:

Simulation is the connective medium between design idea and hardware manufacturing. We have simulated this Yagi-Uda antenna using 4NEC2 software, which is developed by Arie Voors. 4NEC2 is very user friendly software we found it easy to handle and develop antenna.

Implementation of conventional wired reflector Yagi-Uda antenna on 4NEC2 provides gain of 8.6 dBi. Framing this in mind, we tried different kind of reflector i.e curved surface reflector to achieve high gain without affecting front to back ratio. This structure shows the increased gain.

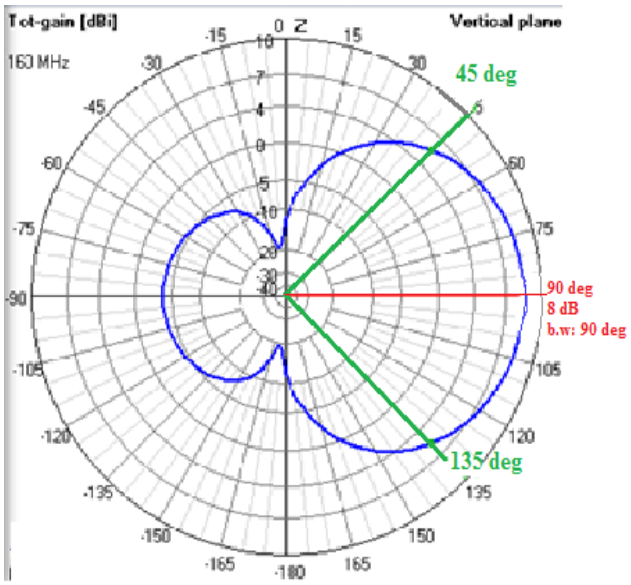

Fig.2 conventional wired reflector results

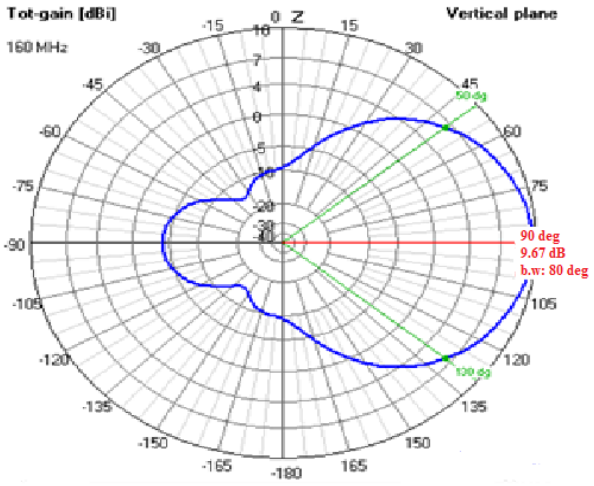

Fig.3 Grid wired reflector results

Comparison of results in figure 2 and 3 shows that gain of antenna is improved from 8dBi to 9.67dBi in figure 3. Use of grid wired reflector results in improvement in gain of antenna. So by implementing curved surface reflector to antenna, gain can be improved.

C. Hardware Design:

Basic element for antenna manufacturing is Aluminium. Aluminium is light weight metal with good strength. It also provides good conductivity. The antenna is manufactured on lathe machine.

Boom is made up of hollow square shape aluminium pipe having dimensions 20*20mm. Five elements are made up of hollow circular shape aluminium pipe. Boom and elements of antenna are connected together with the help of Bush. The bush is solid aluminium metal.

Feed box is made up of plastic which helps to isolate boom and driving element of antenna. The connections are made with use of threading feature, so as to make antenna compact for portability.

D. Experimental Results:

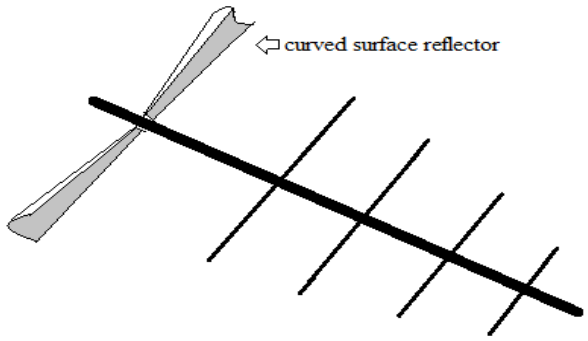

Fig.4 Yagi-uda antenna with curved surface reflector

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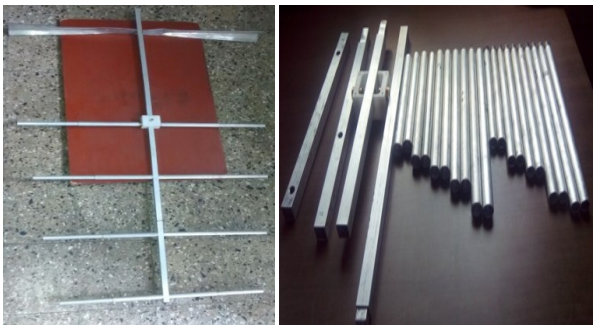

Fig. 5 Fabricated Yagi-Uda Antenna and its portable form

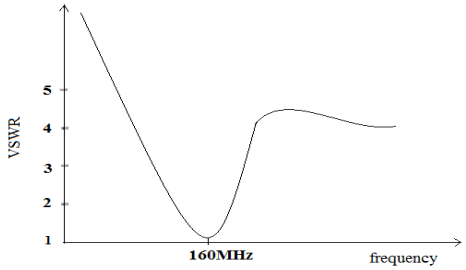

Fig.6 VSWR for curved surface reflector

As shown in figure 6, VSWR is achieved 1.3 which is measured on Network Analyzer. This VSWR is acceptable for our application.

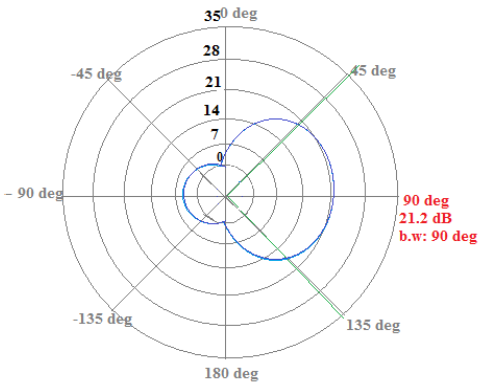

Fig.7 experimental radiation pattern of Yagi-Uda antenna with curved surface reflector

III. Polarization

Antenna polarization is an important factor when selecting and installing an antenna, which helps us to maximize the performance of wireless communication. We have used Vertical Polarization.

A vertical polarization antenna has its electric field perpendicular or at 90^0, to the surface of the earth. Vertical polarization is effective in rural areas, especially where the topography includes Hills or Mountains, and is used for most surface to surface communication in the range of 30MHz above.

IV. Impedance Matching

There are many techniques of impedance matching such as Balun transformer, quarter wave transformer. Balun transformer of 75/50 Ohm was not easily available in India, so we decided to use quarter wave transformer.

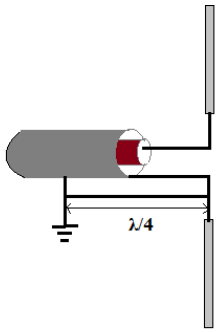

Fig.8 Quarter wave transformer

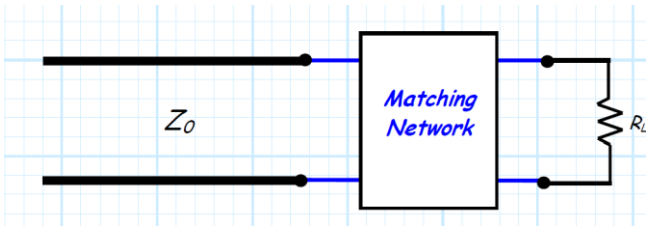

Fig. 9 Impedance matching network

The quarter-wave transformer is simply a transmission line with characteristic impedance Z1 and length L= λ /4.

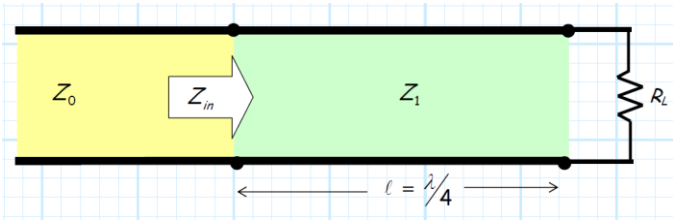

Fig.10 quarter-wave transformer illustration

From figure 10 ,Z0= Zin= 50 0hm and R_L=72 ohm.

$$Z_{in} = \frac{(Z_1)^2}{Z_L} = \frac{(Z_1)^2}{R_L}$$

$$(Z_1)^2 / R_L = Z_0$$

$$(Z_1)^2 = Z_0 R_L$$

$$Z_1 = \sqrt{Z_0 R_L}$$

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Therefore from above equations, Z1=60 ohm and we have used RG58 cable with 50 ohm impedance. So it is nearly matched with characteristic impedance.

V. CONCLUSION

In this work, a unique technique i.e. curved surface reflector is introduced to reduce number of directors and improve the gain of Yagi-Uda antenna. When the numbers of directors are increased, the size of antenna becomes bulky and HPBW also reduces.

To improve the gain of antenna different structures of reflectors have been used. For the grid structure gain is improved as compared to conventional structure. For the advanced development of antenna curved surface reflector is used and maximum gain is achieved without disturbing the other parameters of antenna like number of elements in the assembly remains same, weight remains same but desired outcomes can be achieved.

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