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Antenna and Wave Propagation

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Abstract - Wireless technology is one of the main areas of research in the world of communication systems today and a study of communication systems is incomplete without an understanding of the operation and fabrication of antennas. The main aim of this paper explain basic introduction of antenna and brief explanation of YAGI-UDA antenna .YAGI-UDA antenna mostly use in communication field today in mostly communication system use YAGI –UDA antenna.

Keywords - YAGI-UDA

I. INTRODUCTION

What is an Antenna?

An antenna is a device for radiating and receiving radio waves. The antenna is the transitional structure between free space and a guiding device.

Fig. 1

The first well-known satisfactory antenna experiment was conducted by the German physicist Heinrich Rudolf Hertz (1857-1894)

Fig. 2

The antenna is actually a transformer that transfers electrical signals (voltages and current from a

transmission line) into electromagnetic waves (electric and magnetic fields), or vice versa.

• Types of Antennas

Antennas can be classified in several ways. One way is the frequency band of operation.

Others include physical structure and electrical/electromagnetic design. Most simple, non-directional antennas are basic dipoles or monopoles. More complex, directional antennas consist of arrays of elements, such as dipoles, or use one active and several passive elements, as in the Yagi antenna. Generally we explain YAGI-UDA antenna.

• YAGI –UDA

The Yagi-Uda antenna - invented in 1926 by Shintaro Uda and Hidetsugu Yagi. The Yagi-Uda antenna is one of the most popular and widely used antennas because of its simplicity, low cost, directional radiation and relatively high gain. From the early stage of its existence, The Yagi-Uda antenna and its variations have been used not only for home TV applications but also for modern wireless communications YAGI-UDA antennas have been widely used for VHF/UHF applications ever since they were introduced by Yagi and Uda. The antenna consists of an array of parasitic elements that include a driven element (fed by the source), a reflector element and one or more director elements. The antenna characteristics are governed by the currents induced in the parasitic elements due to the fields produced by the driven element.

A Yagi-Uda array, commonly known simply as a Yagi antenna, its Configuration normally consists of a number of directors and reflectors that enhance radiation in one direction when properly arranged on a supporting

structure. Yagi-uda antenna is a directional antenna system consisting of an array of dipoles and additional closely coupled parasitic elements usually a reflector and one or more directors

Fig. 3 : 3-Element yagi-uda beam antenna

The yagi antenna's basic design is a "resonant" fed dipole with one or more parasitic elements. These parasitic elements are called the "reflector" and the "director." A dipole will be "resonant" when its electrical length is $1/2$ of the wavelength of the frequency applied to its feed point. The yagi-uda array can be summarized by its performance considering in three parts Reflector Feeder or dipole director the length and spacing of the reflector do affect the forward gain but have large effects on the backward gain (F/B ratio) and input impedance (Z_{in}). Thus they can be used to control or optimize antenna parameters.

The driven element is typically a $\lambda/2$ dipole or folded dipole and is the only member of the structure that is directly excited -electrically connected to the feed line. All the other elements are considered parasitic. The feeder length and radius has small effects on the forward gain but a large effect on the backward gain and input impedance. Its geometry is usually chosen to control the input impedance that most commonly is made real (resonant element). The length and spacing of the directors have large effects on the forward gain, backward gain ratio and input impedance. They are considered to be the most critical elements of the array.

YAGI-UDA antenna types-

- 2 elements YAGI-UDA
- 3 elements YAGI-UDA.

Now we discussed 3 elements YAGI-UDA antenna a three-element Yagi-Uda antenna can be used in many applications in communication field.

II. DESIGN PROCESS OF 3-ELEMENT YAGI-UDA ANTENNA

The main requirements for the design of 3 element Yagi antenna are the following

- Element gain
- Front to back ratio
- VSWR
- Impedance

- Design considerations

The dimensions of the elements are frequency dependent.

Here the general rules for length are

Reflector length $-0.495 \times \text{wavelength}$

Dipole length $-0.473 \times \text{wavelength}$

Director length $-0.440 \times \text{wavelength}$

Getting right length is the part of tuning; Spacing between the elements is the other part. Reflector to Dipole spacing $-0.125 \times \text{Wavelength}$

Dipole to Director Spacing $-0.125 \times \text{Wavelength}$

Design frequency around 200MHz

$$\lambda = c/f$$

λ - Wavelength in meters

c- Velocity of propagation in air ($3 \times 10^8 \text{m/s}$) f-Carrier frequency in MHz

Specifications of 3-element Yagi antenna Frequency of operation: 200MHz

Gain: 7dBi F/B

Ratio: 15dB

VSWR: 1.5:1

A three element Yagi antenna is designed and simulated.

The design parameters are

- Reflector length
- Dipole length
- Director length
- Reflector to dipole spacing
- Director to dipole spacing
- Radius of the elements the feeding of RF power to the YAGI antenna is through a coaxial cable.

- Design Specifications

For antenna gain of the order of 7dBi, it is decided to develop a three element Yagi- Uda array antennas.

LR = Reflector length = 0.7425m

LE = Driven element length = 0.7095m

LD = Director Length = 0.66m

S1=Spacing between reflector and driven element=0.2m

S2= Spacing between Director and driven element
=0.2m

III. SOFTWARE SELECTION FOR SIMULATION

The software used to model and simulates the Yagi-Uda antenna was 4NEC2. It can be used to calculate and plot Gain, Front to back ratio, RL (Return Loss), VSWR (Voltage Standing Wave Ratio), Radiation pattern (Azimuth and Elevation), Smith chart and various other parameters.

Numerical Electromagnetic Code The 'Numerical Electromagnetic Code', which is based on Moment Method is a user-oriented computer code for analysis of the electromagnetic response of antennas and other metal structures. It's a software program developed at Lawrence Livermore Lab for numerical electromagnetic antenna design, antenna modelling, and antenna analysis. 4NEC-2 Software based on Method of Moments has been used to carry out the simulations in this present work.

Fig. 4 : Geometry of 3-Element beam antenna

IV. RADIATION PATTERN OF 3-ELEMENT YAGI-UDA ANTENNA:

The radiation pattern (or) antenna pattern is the graphical representation of the radiation properties of the antenna as a function of space that is the antenna pattern describes how the antenna radiates energy out in to space or how it receives energy. The below radiation pattern shows gain, beam width and Front to Back ratio.

Fig. 5 : Radiation pattern response

The most popular antenna specification is the front to back ratio. It is defined as the difference in dB between the maximum gain or from of the antenna – usually 0degrees-and a point exactly 180degrees behind the front. The simulated front to back ratio for 3-element yagi-uda antenna is 17.78dB at 200MHz.

VSWR is a measure of the mismatch between the load and the transmission line. The VSWR of the antenna can be considered and desirable as if it is less than 2. In this below standing wave ratio vs. frequency graph shows the VSWR is 1.62 at 200MHz.

Fig. 6 : Standing Wave Ratio Vs Frequency response

• 3-ELEMENT YAGI -UDA ANTENNA WORKING:

3 elements Yagi Beam antenna working on 27 MHz band with Gamma Match System. It has been completely made of anti corodal aluminium and supplied with big section Boom and steel bracket for the fitting on the support mast. The fixing part with rapid mounting system is made of die-cast metal to get the maximum strength. Every element is supplied with jointing sleeves of polythene for a perfect water-proofing. It's supplied with UHF Female connector.

V. SPECIFICATIONS

• Electrical Data

Type:

Frequency Range: 3 Elem. Yagi Beam Antenna

Impedance : 26.1-27.7 MHz @ $SWR \leq 2$

Radiation : 50 Ω

Polarization : Directional

Gain : 8.5 dBd - 10.65 dBi

Bandwidth @ $SWR \leq 2$: ≥ 1800 KHz (160 channel)

SWR @ res. Freq : ≤ 1.2

Max Power : 1000 Watts (CW) continuous,
3000 Watts (CW) short time

Front to Back Ratio : 20 dB

Connector : UHF Female

• Mechanical Data

Materials : Aluminium, Nylon, Steel

Wind Load / Resistance: 86 N at 150 Km/h / 120 Km/h

Wind surface : 0.07 m²

Dimensions (approx) : 5740 x 2710 x 100 mm

Boom Length / Diameter : 2710 mm $\square$ 33 mm

Max. Element length : 5740 mm

Element Diameter : $\varnothing$ 8-12-16 mm

Turning Radius : 3350 mm

Weight (approx.) : 4700 gr

VI. FINAL COMMENT

This paper reports the design of a Basic Introduction of Antenna and explanation of YAGI – UDA antenna which used mostly in communication .In this report we will explain basics of 3 –element YAGI – UDA antenna and also explain designation and installation of 3-element YAGI –UDA antenna.

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