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A Review on Recent Ternds and Developments in the Design and Application of Yagi Uda Antenna

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Abstract: *The basic components of any communication system that act as connecting links between the transmitter and free space or free space and the receiver are called antennas .There are many type of antennas. Yagi Uda antenna is an important type of antenna.Yagi Uda antenna has many advantages over other conventional antennas and thus they have a wide range of applications. This paper gives a review about the recent trends and developments in the area of Yagi Uda antenna design ,simulation and development.*
Key terms: *Antenna, Yagi Uda antenna, Simulation, Design*

I. Introduction

Antennas are the part of wireless communication systems that converts the electronic signals (propagating in the RF Trans-receiver) into Electromagnetic Waves (Propagating in the free space) .The selection, position and design of the antenna suite heavily influences the performance characteristics of the parent system. Antennas can be classified based on Frequency, aperture, polarization and radiation pattern. The performance parameters of antennas are Gain, Directivity, Beam area and beam efficiency, radiation pattern, VSWR/Return loss, polarization and Efficiency. One of the most important type of antenna is the Yagi-Uda antenna. These antennas are used in fixed-frequency applications as the frequency range over which it has high gain, is narrow, a few percent of the center frequency, and decreases with increasing gain.

II. Yagi Uda Antenna

Yagi-Uda antenna is a directional antenna consisting of multiple parallel dipole elements in a line. A Yagi-Uda antenna consists of a single driven element , a reflector and one or more directors. Reflector element is slightly longer than the driven dipole, whereas the directors are a little shorter. A substantial increase in the antenna's directionality and gain can be achieved using this design.Yagi-Uda antenna was invented by Shintaro Uda and Hidetsugu Yagi in the year 1926and were first widely used during World War II in radar systems. After that these antennas were used in war they saw extensive development as home television. Yagi-Uda antenna is also called as "beam antenna",The antenna is used as a high-gain antenna on the HF, VHF and UHF bands. The Yagi-Uda antenna has a moderate gain which depends on the number of elements. The physical structure of the Yagi-Uda antenna can be explained below. It consists of a single driven element driven in the center and a variable number of parasitic elements, a single reflector on one side and optionally one or more directors on the other side. The parasitic elements serve as resonators, reradiating the radio waves to modify the radiation pattern and are not electrically connected to the transmitter or receiver. The spacings between elements vary depending on the design. The directors has a length slightly shorter than that of the driven element .The reflector(s) has a length longer than that of the driven element. The Yagi Uda antenna has a unidirectional radiation pattern ..The gain of the antenna can be increased by increasing the number of parasitic elements used. The bandwidth of the antenna gets narrowed as the number of elements used increases . The size of the reflector will be 5% longer than the driven element and the directors will be 5% shorter. The length of the Driven Element, the length of the Directors, the length of the Separation between Directors, the length of the Radii of directors and the length between driven element and parasitic elements are the important physical parameters to be considered while designing a Yagi Uda antenna.

III. Working Principle

The driven element of the Yagi Uda antenna is the only member of the structure that is directly excited and all the other elements are considered parasitic, that reradiate power which they receive from the driven element The parasitic element is a normal dipole element fed at its centre, with a short circuit across its feed point. A short circuit reflects all of the incident power 180 degrees out of phase. The operation of the parasitic element can be modeled as the superposition of a dipole element receiving power and sending it down a transmission line to a matched load, and a transmitter sending the same amount of power up the transmission line back toward the antenna element. The superposition of the two voltage waves would give zero if the transmitted voltage wave were 180 degrees out of phase with the received wave at that point. The reflector element has an inductive reactance .This means that the phase of its current lags the phase of the open-circuit voltage that would be induced by the received field. The director element has a capacitive reactance with the voltage phase lagging that of the current. The radio waves radiated by the driven element and those reradiated by the parasitic elements all should arrive at the front of the antenna in phase, so they superpose and add, increasing signal strength in the forward direction. In order to achieve this,the elements are given the correct lengths and spacings.

IV. Advantages And Application Of Yagi Uda Antenna

Yagi-Uda antennas are directional antennas. They are used for such applications as radio location,data communications and TV receiving antennas. Yagi-Uda antennas they are usually employed in HF,VHF and UHF systems . These antennas are also recently used in data transmission in sensor networks and RFID applications where the radiated power of the source is very limited. Yagi-Uda Antenna is widely used due to its high gain capability, low cost and ease of construction. These antennas are used in systems where the range of frequencies in use is fairly small. The Yagi Uda antenna provides long range and high rejection . The tight RF bandwidth and narrow beam-width is the most highlighting feature of the Yagi Uda antenna.Optimization of the Yagi-Uda Antenna can be achieved by simulating the radiation patterns for various lengths of the elements and the spacing between them.

V. Recent Trends

Due to the large number of advantages and applications of the Yagi Uda antenna many research has been done on the yagi uda antennae to improve the efficiency and performance .Additional applications of yagi uda antennae has been developed as a result of advanced research and studies. Many papers has been published about developments in application and design of yagi Uda antenna. A compact planar directive Yagi-Uda antenna for A modified two-element Yagi-Uda antenna with tunable beams in the H-plane that includes forward, backward, omni-directional, and bi-directional beams were designed and simulated. The short-circuit position of the transmission line connected to the parasitic element is adjusted to obtain the tunable beams. The current relations between the driven and parasitic elements where studied. The physical dimensions of the antennae was a important design feature .The length of the driven element was 162.3mm, the length of the parasitic element was 148.2mm the length of the Separation between the two elements was 77.7mm the length of the Length of the balun was 87mm, the length of the Radius of the driven element was 1.05mm , the length of the Radius of the parasitic element was 1.05mm, the length of the Radius of the balun was 1.05 mm, the length of the Radius of the transmission line was 1.05 mm, the length of the Separation of the balun was 10mm and the length of the Separation of the transmission line was 10mm[2].

A compact linearly polarized high gain antenna for a handheld UHF RFID reader using a Yagi Uda type antenna with physical dimension of 100 mm x 100 mm was developed. A gain of 6 dB and VSWR better than 1.3 in approximately 50 MHzband around either European or US RFID bands(865- 870 MHz or 902-928 MHz) was obtained [3]. A high bandwidth Yagi-Uda antenna embedded on a microstrip chip for dedicated short-range communications was designed and developed.. The Yagi - Uda microstrip antenna developed had a bandwidth of 33.09% , better gain and front to back ration over a fractional bandwidth superior than 33% with voltage standing wave ration of more than or equal to 2:1.Due to its small size and improved bandwidth the developed antenna was recommended for in the field of short – range wireless communication[4]. A 60-GHz millimeter-wave on-chip Yagi Uda antenna fabricated with a 0.18-μm CMOS process. Coplanar waveguide (CPW)technology is use to design the feeding network . Thephysical dimension of the antenna was 1.1 × 0.95 mm2. The antenna input VSWR was less than two from 55 to 65 GHz. The measured maximum antenna power gain is about −10 dBi. The radiation efficiency was about 10%[5]. A novel broadband planar antenna based on the classic Yagi–Uda dipole array was developed. This antenna achieved 48% bandwidth for VSWR 2, better than 12 dB front-to-back ratio, smaller than 15 dB cross polarization, 3–5 dB absolute gain and a nominal efficiency of 93% across the operating bandwidth. Optimization of the antenna is done using finite-difference time-domain. A gain-enhanced design is presented.Higher gain has been achieved at the cost of reduced bandwidth. The antennas were realized on a high dielectric constant substrate . These antennas are completely compatible with microstrip circuitry and also with solid-state devices[6] .The overall dimension of a microstrip antenna was reduced using a partially filled high-permittivity substrate. A microstrip Yagi Uda antenna with reduced size for a repeater system in a mobile communication cellular band (824–894 MHz)was designed .The antenna manufactured accourding to thus design was lightweight and smaller in size[7] .

A Microstrip Yagi-Uda antenna, operating very near to resonant frequency 900MHz with relative permittivity 2.2 for RT Duroid 5880 substrate, height of substrate 1.575 mm, characteristicimpedance 50 ohm and thickness of strip conductor 35μm was developed. To have low profile, Yagi Uda antennas are implemented using microstrip circuits. The gain of an antenna array with a very simple feeding can be enhanced by using this type of structure. The antenna consisted of patch as a driven element, and printed dipole for parasiticelements . The design enable the manufacturing of the antenna at low cost. A gain of 8.33 dB is obtained.

Increaseddirectivity in the direction of satellites can be obtained for ground station application. The performance can be further improved byapplying defective ground structure or frequency selective surface. Minimization can be obtained by optimizing dipoles width[8]. An Ultra Wide Band Microstrip Yagi Uda antenna was developed with very good performance at theoperating frequencies 0.85, 2.4, 3.5 and 5.2 GHz. A 20 to -40 dB return loss at the bands 0.85, 2.4, 3.5, 4.5 and 5.2 GHz and VSWR less than 1.7 at these frequencies were obtained from the simulation results. Finite element method (FEM) of simulation was applied by using HFSS simulator to obtain the optimized parameters so that the best design for the antenna can be obtained [9].

A planarsix element microstrip Yagi-Uda antenna is successfully simulated and developed. The microstrip Yagi-Uda antenna developed was a highly directional antenna operating at a frequency of 6.52 GHz. CST simulation software was used to simulate the antenna. The substrate used for fabricating the antenna was FR4 having a dielectric constant of 4.3, supported substrate thickness of 1.6mm and loss tangent of 0.02. The antenna has a wideband and directional radiation pattern with very high gain and effective radiation efficiency. The antenna can be effortlessly used it C-Band of Microwave frequency. Depending up on the applications gain of this antenna can be varied by varying dimensions of its ground-plane[10]. A dual-frequency circularlypolarized electronically steerable microstrip patch antenna array was developed which is suitable for land-mobile communications. The four antennas forming the array are located radially from a single square reflector patch on a double-sided printed circuit board based on a four element Yagi-Uda patch antenna,. The main lobe of the array covers the elevation angles from 20 to 70. A peak gain of 8.4 dB is obtained at a frequency of at 1.54 GHz and a peak gain of 11.7 dB is obtained at a frequency of 1.62 GHz. By electronically switching between the four elements, a full azimuthal coverage is made possible [11].

A compact 3D U-shaped Yagi-Uda antenna with different high permittivity and permeability materials was developed and studied. Antennas made of material with high permittivity and permeability dielectrics which allow the enhancement of light and high frequency RF communication and sensing are required for high speed data processing at nanometer wavelength. The main important feature of the Optical Yagi- Uda antenna is its unique directive property which mobilizes the concepts of beam forming and beam scattering .ANSYS HFSS v15.0 simulation software is the software that is used for the simulation of this antenna with the changes in dielectric permittivity and permeability and the spacing between the elements is relying on the operating wavelength [12]. A printed Yagi-Uda antenna with an integrated balun for WLAN applications was designed and simulated. The operating frequencies of the planar directive antenna is designed at 2.4 GHz and 5 GHz frequency bands. The feed to the antenna is an integrated balun in the form of microstrip-to-coplanar strips (CPS) transition. FR4 with a dielectric constant of 4.4 and thickness 1.6mm is used as the substrate[13]. A high gain broadband Yagi-Uda antenna for wireless communication application at frequency of 5.2 GHz was developed. The simulation software used for the design of the antenna was HFSS simulation software. FR-4 with dielectric constant of 4.4 and height of 1.6 mm is used as the substrate used to design the antenna. A high gain with wide bandwidth can be obtained by using this antenna[14].

A microelectromechanical system (MEMS) reconfigurable Yagi Uda antenna with a new architecture was designed and simulated. The antenna designed is a reconfigurable Yagi-Uda antenna with one dipole, one reflector and three directors.The antenna is designed in a micro scale such that it changes the length of those elements according to the desired frequency in the range from75 to 100GHZ. [15]A microstrip Yagi-Uda array design has been simulated at frequency of 6.95 GHz. The software used for simulation of Yagi Uda array is the CST MW Studio Software. The reflector, directorand driven element are designed by using microstrip patches of different dimensions. The substrate is FR-4 lossy at height1.6mm and loss tangent of 0.02. Very high gain and effective radiation efficiency can be achieved by this design. The antenna has a very less return and very good compatibility with microwave circuitry[16]. A Yagi-Uda Ultra Wide Band Micro strip antenna operating frequencies 7 GHz was developoed. The designed antenna has a antenna good front to back ratio and good return loss of 7 GHz and VSWR less than 1.7 at these frequencies. The antenna has two sections of reflector element and one driven element and one director. Micro strip line is used to feed the antenna. ANSOFT HFSS-13 design software is used[17].

VI. Comparison Table

ANTENNA	SUBSTRATE	PHYSICAL DIMENSION(mm)	GAIN (db)	OPERATING FREQUENCY	APPLICATION	DESIGN TOOL	JOURNAL
Compact Planar Directive Yagi Antenna For Wlan Application	FR4 of dielectric constant 4.4	24 mm x 30 mm	5	5 GHz	WLAN	CADFEKO software.	International Journal of Electrical, Electronics and Data Communication
Modified Two-Element Yagi-Uda Antenna With Tunable Beams	-	L1 -162.3 L2-148.2 Sp- 77.7 Sb -87 a -1.05 b -1.05 c-1.05 d- 1.05 Wb-10 Wd-10 St- 74	-	850MHz	modern wireless communication systems	NEC software, method of moments-based numerical electromagnetic code (NEC)	Progress In Electromagnetis Research
Compact Yagi Antenna for Handheld UHF RFID Reader	ABS plastic (dielectric permittivity 3.5)	100 mm x 100 mm	6	US and European (ETSI) UHF RFID bands (902-928 MHz and 865-870 MHz)	UHF-RFID Reader	HFSS	Intermec Technologies, Everett, WA 98203
High Bandwidth Yagi-Uda Antenna For Dedicated Short Range Communications	-	-	10	high frequency (HF) and Ultra-high frequency (UHF) bands, usually between 3 MHz to 3 GHz.	Short range communication	High Frequency Structure Simulator (HFSS) software	International Journal of Computer and Communication System Engineering
A 60-Ghz Millimeter-Wave CPW-Fed Yagi Antenna Fabricated By Using 0.18-Mm CMOS Technology	-	The CMOS antenna chip size is 1.1mm × 0.95 mm	10	60GHZ	WPAN	The HFSS FEM-based 3-D full-wave electromagnetic solver is used for the design simulation.	IEEE electron device letters

A Broad-Band Planar Quasi-Yagi Antenna	Duroid with dielectric constant 10.3	W1 = W3 = W4 = W5 = Wdri = Wdir = 0:6, W2 = 1:2, W6 = S5 = S6 = 0:3, L1 = 3:3, L2 = L5 = 1:5, L3 = 4:8, L4 = 1:8, Sref = 3:9, Sdir = 3:0, Ssub = 1:5, Ldri = 8:7, and Ldir = 3:3.	3-5	9.5GHz	High Gain Applications	-	IEEE Transactions On Antennas And Propagation
Design And Development Of Microstrip Yagi-Uda Array For 900mhz Frequency	RT Duroid 5880 substrate	L = 110.8mm, W=131.8mm	8.33	900MHz	Industrial and Medical Application	Ansoft HFSS	IEEE Sponsored International Conference on Innovations in information,Embedded and Commn-S/ms
A Novel Ultra Wide Band Yagi Microstrip Antenna For Wireless Applications	-	-	-	(0.85, 2.4, 3.5, 4.5 and 5.2) GHz	Ultra Wide Band Applications	HFSS	Journal of Theoretical and Applied Information Technology
Highly Directional C-Band Planar Six Element Microstrip Yagi-Uda Antenna	(FR-4, lossy) with dielectric constant of 4.3,	L=5.8,L1=2.5 W=1.0, W1=0.6, S1= 0.87, S2=2.8, S3=3.4, S4=2.4, L1=3,V=2, X=2.5, Y=3,Z=3.5	-	6.25GHz	C-Band Applications	HFSS	International Journal of Emerging Technology & Research
Yagi Uda Antenna With Integrated Balun For WLAN Application	FR4 of dielectric constant 4.4	24mm x 24mm	4 – 4.5	2.4 GHz and 5 GHz	WLAN	CADFEKO software.	International Journal of Computer Applications
Design Of 5.2 Ghz Yagi-Uda Antenna	FR-4 with dielectri	-	7	5.2GHz	WLAN, NGMN and other wireless	HFSS	International Journal of

For Wireless Communication Application	c constant of 4.4				communication applications		Advanced Research in Electronics and Communication Engineering
Microstrip Patch Yagi-Uda Array For Millimeter Wave Applications	FR4	L=85,W=40, L1=9.5,W1=14,L2=12.6, W2=17,L3=15.6,W3=20.45,L4=,W4=31.8.	4.76	6.95GHz	Industrial and medical Applications	CST simulation software.	International Journal of Engineering Research and General Science
A New Yagi-Uda Microstrip Antenna With Good F/B Ratio	RT Duroid 5880 which has relative permittivity 2.23.	L= 14.038 mm PD=10.74mm PR=11.277 mm PR1=5.6385 mmPR1=5.6385mm PP=10.203mm W= 16.595mm	-	7GHz	Ultra Wide Band Application	ANSOFT HFSS-13	International Journal of Scientific & Engineering Research

VII. Conclusion

Yagi uda antenna is a very important type of antenna that finds application in different areas of wireless communication.Due to this immense advantages and applications, many research and studies has been conducted on this antennae.Design of yagi Uda antenna for applications other than the conventional ones are discussed in many papers.This paper put forward a summary of recent developments and studies that has been occurring in the application and design of Yagi Uda antennae

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