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Design of Folder Reflector Yagi Uda Antenna for IMT Band Frequency

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Abstract: Microstrip antennas were first investigated from that idea that it would be highly advantageous to fabricate on the same dielectric substrate. Other advantages were soon discovered to be its lightweight, low profile, conformability to shaped surfaces, and low fabrication costs. Unfortunately, these same patches continually exhibit narrow bandwidths, wide beam widths, and low antenna gain. This project is concerned with investigations of microstrip Yagi antenna that are to be used at range 1.8 GHZ This antenna has been fabricated with a high dielectric constant substrate material(Rogers TMM 4(tm) with dielectric constant ε_r=4.7) ,substrate thickness of 5mm.This has successfully produced antenna at frequency 1.8 GHZ with minimum return loss -10dB, antenna bandwidth minimum is 2% with radiation efficiency more than 90% and validated it's potential to be operated on IMT band. Generally, the trade-offs in this design are between size, simplicity and performance.

Keywords: Yagi Uda antenna, Strip-line, VSWR, S-Parameters, Ansoft HFSS Tool.

I. Introduction

Communication can be broadly defined as the transfer of information from one point to another .A communication system is usually required when the information is to be conveyed over a distance. The transfer of information within the communication system is commonly achieved by superimposing or modulating the information onto an electromagnetic wave which act as a carrier for the information signal. At the required destination, the modulated carrier is then received and the original information signal can be recovered by demodulation. Over the years, sophisticated techniques have been developed for this process using electromagnetic carrier waves operating at radio frequencies as well as microwave and millimeter wave frequencies

In today's modern communication industry, antennas are the most important components required to create a communication link. Through the years, microstrip antenna structures are the most common option used to realize millimeter wave monolithic integrated circuits for microwave, radar and communication purposes [1]. Due to its many advantages over the conventional antenna. The microstrip antenna have achieved importance and generated interest to antenna designers for many years. In fact, active microstrip antenna arrays and active apertures are increasingly present in phased array radar applications. In addition, these devices also serve as potentially efficient power combiners. Hence, active microstrip antennas arrays are often used in spatial or "quasi-optical" combining schemes for creating high power and high-frequency components. Furthermore, microstrip antennas are often used in military air craft, missile, rocket and satellites.

The concept of antennas was first proposed by Deschamps as early as 1953, Gutton and Bassinot in 1955 .However, not much carry-on researches have been carried out until 1972. Since then, it took about twenty years before the first practical microstrip antennas were fabricated in the early 1970's by Munson and Howell first presented the design procedures for microstrip antennas whereas Munson tried to develop microstrip antennas as low profile flushed-mounted antennas on rockets and missile. In addition, research publications regarding the development of microstrip antennas were also published by Bahl and Bhartia and James [2] ,Hall and Wood Dubost had also published a research monograph which covers more specialized and innovative microstrip developments .In fact ,all these publication are still in use today .In October1979,the international meeting devoted to microstrip antenna materials, practical designs, array configurations and theoretical models was held at New Mexico state University under sponsorship of the us army research office and New

Mexico state University's Physical Science Laboratory. In 1979, Hall reported the design idea of electromagnetically coupled patch antenna and proved experimentally that it is able to possess higher bandwidth while maintain a simple fabrication process [3]. The early 1980 was not only a crucial point in publication but also milestone in practical realism and manufacturing of the microstrip antennas present –day system requirements are an important factor in the development of printed antennas .since then, antenna researchers began to take an interest in 'antenna array architecture', which has emerged as a dominant approach to the micro strip world [4].

II. MICROSTRIP ANTENNA

In today's aircraft and spacecraft application where the antenna's size, weight, cost, performance, ease of installation and aerodynamics profile are of utmost consideration low-profile microstrip antenna is preferred over conventional antennas [5]. The term 'microstrip' actually refers to any type of open wave guiding structure which is not only a transmission line but also used together with other circuit components like filter ,couplers, resonators, etc .In fact, microstrip antennas are an extension of the microstrip transmission line. Microstrip antennas can be flush-mounted to metal or other existing surfaces, and they only require space for the feed line, which is usually placed behind the ground plane. On one side of dielectric substrate, this has a ground plane on the other side. The patch conductors usually made of copper or gold can b virtually assumed to be of any shape. However, conventional shapes are normally used to simplify analysis and performance prediction. The radiating elements and the feed lines are usually photo etched on the dielectric substrate

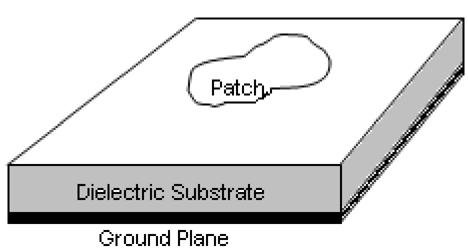

Fig 1. Microstrip Patch Antenna

The upper surface of the dielectric substrate supports the printed conducting strip while the conducting ground plane backs the printed conducting strip while the conducting ground plane backed the entire lower surface of the substrate. The radiating patch may be square, rectangular, circular, and elliptical or any other configuration. Square, rectangular and circular shapes are the most common because of ease of analysis and fabrication. As for the feed line, it is also a conducting strip; normally of a smaller width coaxial line feeds where the inner conductor of the coax is attached to the radiating patch are also widely used. Sometimes, microstrips are also referred as printed antennas.

III. YAGI ANTENNA

The microstrip yagi is proven to provide a relatively large gain and has a main beam that is away from broadside and therefore would satisfy the requirements of the system. A yagi array having a single reflector and director will have a gain of 7 dBi and a main beam width of 30^0 from broadside. Then, by using an array of four such of antennas, the 16 dBi requirements will be fulfilled.

The principle of the operation of the microstrip yagi antenna is by means of surface wave coupling between the driven element and parasitic elements for this coupling to be significant a thick substrate with the dielectric substrate larger than 1.5 has to be used. The material that was used is material (Rogers TMM 4(tm) with dielectric constant ε_r=4.7) with substrate thickness of 5mm. Because of coupling between the driven element and the parasitic element of the yagi uda antenna, coaxial feeding will affect the surface waves that are responsible for it. The input impedance at the location of the each probe is matched 50Ω. The feeding network is deigned and implemented on a separate substrate and shares the ground plane with the antenna circuit. Coaxial feeding is employed to provide equal phase and equal amplitude excitation to the three elements of the array.

The rapid growth of technology required of various wireless communication systems demand efficient antennas to establish an adequate communication link [6]. Nowadays, many contributions have taken place in the design and optimization of printed microstrip Yagi antenna. John Huang [7] introduced the first standard design in 1989 for mobile satellite (MSAT) applications, which required a low-cost and low-profile antenna that covers a 30° beam width. Since Huang's initial design, there have been some modifications to this antenna design process and configuration to address these limitations. Padhi and Bialkowski developed a periodic band gap (PBG) structure that can be applied to microstrip Yagi antenna arrays for reducing the cross polarized radiation and increasing the gain. Dejean and Tentzeris developed a printed microstrip Yagi antenna array that can achieve a gain above 10 dB and a high FIB ratio (as much as 15 dB) that can be used for ISM, HIPERLAN, and millimeter-wave applications above 30 GHz.

A Yagi-Uda (Yagi) antenna is a parasitic linear array of parallel dipoles used to generate end-fire beam formation. A traditional Yagi antenna consists of a driven element, a reflector, and one or more directors. This antenna structure is simple to build, lightweight, and low cost. The reflector and directors are not driven directly, but instead couple parasitically to the driver. It is well known from antenna theory that the Yagi antenna is primarily used to achieve end-fire radiation by satisfying appropriate amplitude and phase conditions (equal amplitude and opposite phase) for the closely-spaced driven element, reflector, and the directors. At the same time, a Yagi antenna can achieve a relatively high gain with low cost. Traditionally, Yagi antennas are designed using wire dipole or printed dipole antennas.

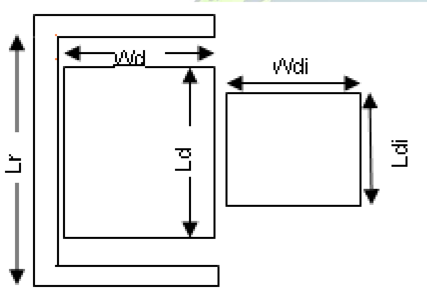

Fig 2. Microstrip Yagi Antenna Model

L_r → Length of Reflector element
L_d → Length of Director element
L_{di} → Length of Director element
W_d → Width of Driven element
W_{di} → Width of Director element

IV. DESIGN METHODOLOGY

Before done any simulation, the antenna parameter must be calculate to get the best performance and operating frequency like expect. This stage were very important for the designing any antenna. The width of the antenna can be calculated by

$$W = \frac{C}{2 f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

$$W = 44.21675mm$$

The effective permittivity is calculated by

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + 12\frac{h}{w}\right)^{-\frac{1}{2}}$$

$$\varepsilon_{eff} = 4.395$$

To calculate the length of the antenna,

$$\frac{\Delta L}{h} = 0.412\left(\frac{(\varepsilon_{eff} + 0.3)}{(\varepsilon_{eff} - 0.258)}\frac{\left(\frac{w}{h} + 0.264\right)}{\frac{w}{h} + 0.8}\right)$$

$$L = \frac{1}{(2 \times f_r)\sqrt{\varepsilon_{eff}}\sqrt{\mu_0 \varepsilon_0}} - 2(\Delta L) = 34.27043mm$$

Therefore Driven element is

$W = 44.21675mm$ and $L = 34.27043mm$

For reflector element

$$\frac{L_r}{W_r} = 1.3$$

$W_r = 57.540275mm$ and $L_r = 44.551559mm$

For Director Element

$$\frac{L_{di}}{W_{di}} = \frac{1}{0.8}$$

$$W = 35.4094mm$$
$$L = 27.416344mm$$

V. SIMULATION RESULTS

By using HFSS software, the antenna will be modeled and are simulated. The micro strip Yagi antenna are simulated at a frequency range of 1.8 GHZ and has been fabricated with a high dielectric constant substrate material(Rogers TMM 4(tm) with dielectric constant ε_r=4.7) ,substrate thickness of 5mm.

The various parameters obtained from these are,

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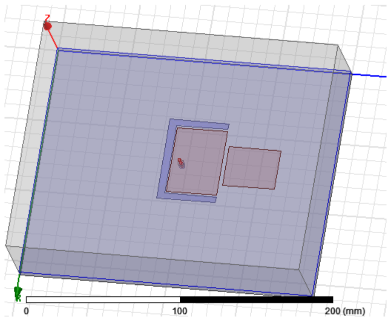

Fig 3. Antenna Model Using HFSS

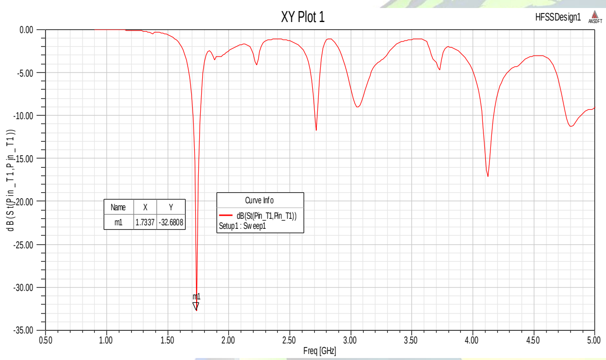

Fig 4. Reflection coefficient of Yagi antenna

The reflection coefficient shows that at a frequency of around 1.73 GHz the reflection coefficient reduces to -32.68 dB.

Fig 5. VSWR of Yagi antenna

The VSWR shows that at a frequency of around 1.73 GHz the reflection coefficient reduces to 0.4035.

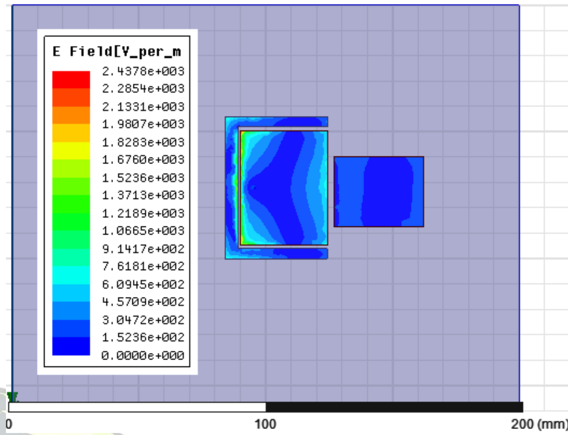

Fig 6. Electric Field Distribution of Yagi Antenna

VI. CONCLUSION

A micro strip yagi uda antenna with three parasitic elements, pair of reflectors and double dipole is designed, simulated, fabricated and measured at 1.78 GHz. The controllability of radiation pattern of antenna is improved by using the folded reflectors with small ground plane. The gain is increases by the Director elements. The return loss of -32.68 dB, directivity of 5.62 dBi and gain of 4.94 dB is achieved by the proposed antenna. So the designed antenna found the application in IMT band such as weather radar and wireless system.

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