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Comparison of Wire-Patch with proposed three notch Multilayer Yagi-Uda structure for C-Band Wireless application

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Abstract:
This paper presents a comparative performance analysis of Yagi wire patch antenna for WiMAX Application. Previous paper presents the design of a low-profile, high-gain Yagi wire-patch antenna array that radiates a directional beam in the azimuthal plane within the frequency band5.45–5.75 GHz. The elementary unit of a typical Yagi antenna is replaced by wire-patch antenna. This antenna delivers a gain of 14.8 dB at 5.6 GHz. Proposed antenna is a Multilayer Yagi-Uda antenna based on coupler line approach, slot, two via and one shorting pin , which is very useful for C-Band and S-Band. This antenna has been used for 10% impedance bandwidth between 3.7Ghz to 4.1GHz, 15.9% impedance bandwidth between 5.2GHz to 6.1GHz and 10% impedance bandwidth between 7.4GHz to 8.2GHz, achieved three notches, first at 3.9GHz, second at 5.6GHz and third at 7.7 GHz, This antenna has been developed at supporting dielectric constant of 4.3 and 2.2, and air gap, The proposed antenna is completely compatible with microwave circuitry and wireless communication system. This antenna is simulated by using IE3D simulation software. This improves the performance greatly to achieve the maximum possible bandwidth within the pass band. The simulation results are good & less return loss.

Index Terms: IE3D Software; Micro-Strip Antenna; Planar Antenna; Wireless Communication, Bandwidth.

I. INTRODUCTION

Yagi-Uda antenna is widely used Among the most prevalent antennas,. Initially, the Yagi-Uda antenna was used for domestic application that is for receiving signals for televisions but sooner they also found there application in wireless system [1-3]. In 1928, first paper based on Yagi-Uda is published in an English language journal [4]. However, only limited success has been achieved at adapting this antenna to microwave/millimeter wave operation. Several interesting approaches for this are a microstrip Yagi array based on the microstrip patch antenna [5], and a coplanar-strip line fed printed Yagi–Uda antenna with the reflector element printed on the back of a thick, low permittivity slab at 60 GHz [6].In recent years, Yagi-Uda antenna or Yagi-Uda arrays came into existence which consist of a driven element and more than one parasitic element [7].Microstrip Yagi–Uda antenna offers advantages such as simple, compact, low cost , high directivity, high gain and wide bandwidth therefore they are widely used in radio frequencies application. The advantage with antennas are that they can be suitably used for wide range of applications such as wireless communications, satellite communications, pattern combining and antenna arrays. The driver and directors components are almost similar in all designs of antennas and the only difference is of feeding.

II. Design and principle:

proposed antenna is modified form of Hongjiang Zhang, Yasser Abdallah, Regis Chantalat, Marc Thevenot, Thierry Monediere, and Bernard Jecko paper of title" Low-Profile and High-Gain Yagi Wire-Patch Antenna for WiMAX Applications". In this design, modifications like substrate thickness (1.6mm) and dielectric constant 4.3, 2.2 and 1, loss tangent (0.019,0005,0) were taken into account. The IE3D simulation software was used for the antenna simulation. This design has been developed at frequency of 5.6GHz. Here, fig. 1 shows Proposed Antenna Geometry micro-strip Yagi-Uda antenna. The size of reflector is 1000 mil x 1100mil, driven element of dimension 700mil x 800 mil, top patch includes thee slots used air gap between FR-4 and RT-Duroid dielectric material. In this proposed antenna the spacing between the directors is independent of the physical length.

Where

Wg = Width of Ground Plane

Lg = Length of Ground Plane

L_D = Length of Director

W_D = Width of Director

W_{Dr} = Width of Driven

L_{Dr} = Length of Driven

Antenna has been measured across the operating bandwidth of C-Band.

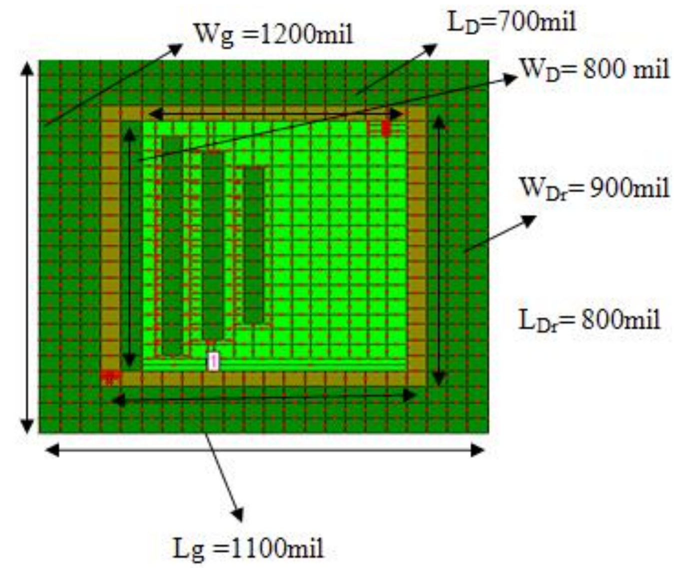

Fig. 1: Proposed Antenna Geometry

The fig. 2 shows the simulated and measured return loss of the proposed antenna. Resonance frequency of the proposed antenna is 5.2GHz. There is slight difference between the simulated and measured results of the antenna because of measuring errors and SMA connector that was used at the time of simulation. Comparison between simulated and measured.

A. Design Via Hole

In RF and microwave circuits, low-loss and low-inductance grounds are very important to achieve good gain, noise figure, insertion loss, VSWR, output power, power-added efficiency (PAE),and bandwidth performance. In MICs/ MMICs, one needs the backside ground metallization to be connected with minimum possible inductance path to the top side of the substrate having RF ground pads. In MICs four basic techniques are used to achieve such ground connections. These are via hole, wire bonds, ribbon bonds, and wrap-around grounds. For RF applications of MMICs, via hole and wire bond techniques are commonly used, whereas via hole is an integral part of monolithic microwave and millimeter-wave integrated circuits.

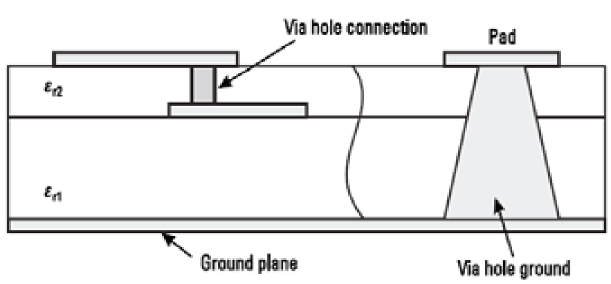

Fig. 2: Via Hole Connection Through Dielectric and Backside Via Hole Ground

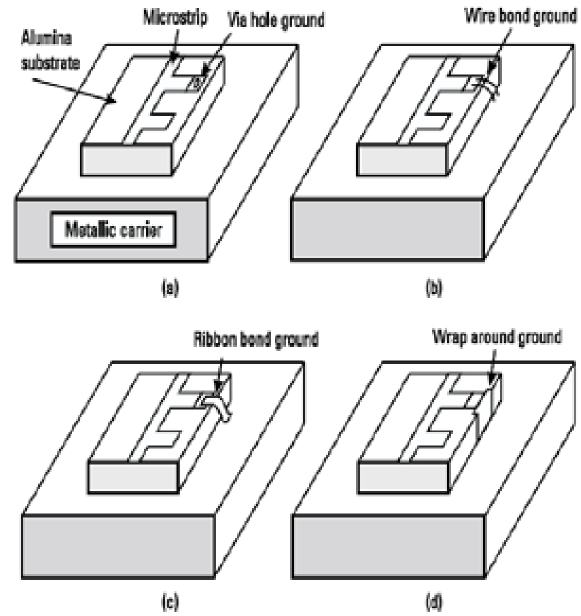

Fig. 3: Various Ground Connection Techniques in MICs: (a) Via Hole, (b) Wire Bond, (c) Ribbon Bond, and (d) Wrap-Around.

B. Analytical Expression

An analytical expression for the inductance, L_{via} of a cylindrical via hole shown in fig. 3 was obtained by Goldfarb and Pucel [3] and is given below.

$$L_{via} = 0.2\left[h - \ln\left(\frac{h+\sqrt{r^2+h^2}}{r}\right) + \frac{3}{2}\left(r - \sqrt{r^2+h^2}\right)\right](pH)$$

where r and h, the radius and height of via hole, respectively are expressed in microns. The resistance of via hole may be approximately calculated using the following expression:

$$R_{via} = R_{dc}\sqrt{1+\frac{f}{f_\delta}}$$

$$f_\delta = \frac{1}{\pi \mu_0 \sigma t^2}$$

Here f is the operating frequency, μ_0 the free-space permeability, s the conductivity of the metal, and t its thickness.

III Result and Discussion

A. Return Loss Vs Frequency

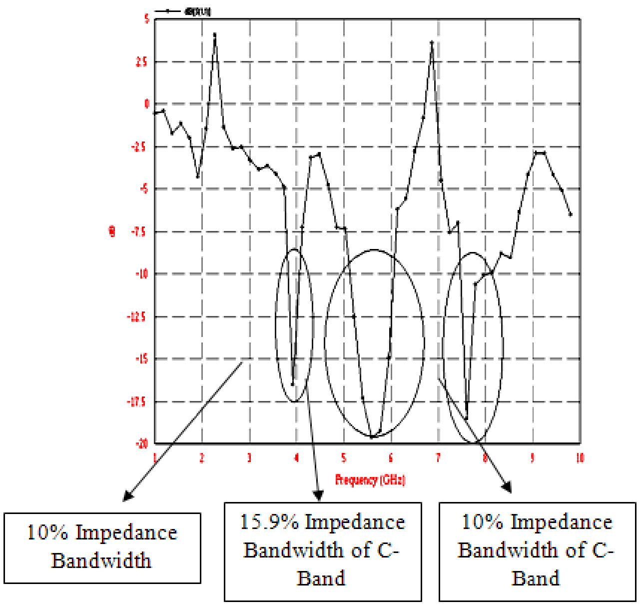

Fig. 4: Frequency Vs Return Loss

Fig. 4 show result of frequency vs return loss of proposed design, Simulated result of antenna shows return loss of -19dB at 5.6GHz while measured result of antenna shows return loss of -18dB at 7.5GHz,and -16.5 dB at 3.9GHz . This antenna has been used for 10% impedance bandwidth between 3.7Ghz to 4.1GHz, 15.9% impedance bandwidth between 5.2GHz to 6.1GHz and 10% impedance bandwidth between 7.4GHz to 8.2GHz, achieved three notches' first at 3.9GHz, second at 5.6GHz and third at 7.7 GHz, fig. 3 and fig. 4 are show radiation pattern and gain respectively. By inspecting graph shown in fig. 4, it is found that gain of Yagi-Uda antenna is 3.9(dBi) fig. 5 shows the smith chart [11] of the antenna, it shows that the impedance of the antenna is matched with the co-axial cable i.e. 50Ω.

B. Directivity Vs Frequency

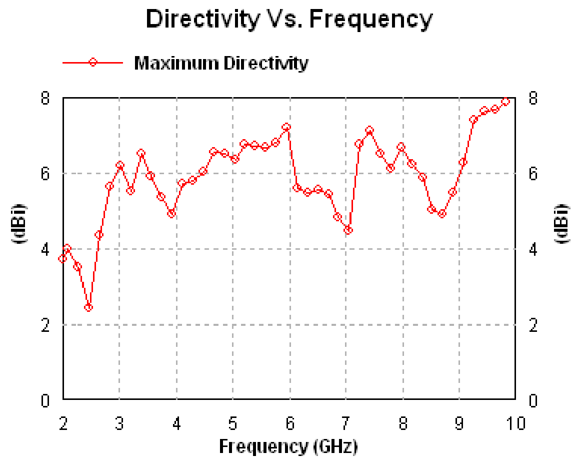

Fig. 6: Directivity Vs Frequency

Directivity of proposed antenna vary from 2.2dBi to 8dBi. Directivity of proposed antenna shown in fig.6.

The results of the proposed design is shown in Table 2
Table 2: Results of Proposed Antenna Design

Freq (GHz)	Directivity (dBi)	Bandwidth %	Radiation Efficiency (%)	Return loss
3.9	5.2	10	65	-16.5
5.6	7	15..9	50	-19
7.5	7	10	99	-18

Antenna efficiency achieved up to 70% and radiating efficiency up to 99%.

TABLE 3: Comparison of Yagi wire patch antenna & Proposed antenna

Parameters	Yagi wire patch antenna	Three notch multi layer micro strip yagi-uda antenna
Number of directors	5	3
Number of bands	1	3
bandwidth	5.35%	10.25%,15.9%,10.25%
Efficiency	92%	99% at 7.5GHz
Type of Feed	SMA coaxial connection	Via hole connection
Dependency of spacing between directors	dependent	independent
Return loss	-17.5dB	-19dB at 5.6GHz
Formation of Director	Using Metallic patch	By cutting Slot

IV. Conclusion

The Multilayer Yagi-Uda antenna based on coupler line approach, slot, two via and one shorting pin is presented which is very useful for C-Band microwave wireless applications. This proposed antenna is designed for C band and S-Band. This antenna has been used for 10% impedance bandwidth between 3.7Ghz to 4.1GHz, 15.9% impedance bandwidth between 5.2GHz to 6.1GHz and 10% impedance bandwidth between 7.4to 8.2GHz, achieved three notches' first at 3.9GHz, second at 5.6GHz and third at 7.7 GHz, This antenna has been developed at supporting dielectric constant of 4.3 and 2.2, and air gap, The proposed antenna is completely compatible with microwave circuitry and wireless Communication system. This antenna is simulated by using IE3D simulation software. The antenna has been simulated using IE3D wide band width in C-Band and well directive radiation pattern, radiation efficiency up to 99% and antenna efficiency of 99%. Directivity of the antenna up to 7dBi ,the return loss of design is-19dB at 5.6GHz, return loss of -18dB at 7.5GHz, and -16.5 dB at 3.9GHz. By this design obtained three notch in C-Band, achieved three bands in C-Band.

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