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UNIPLANAR QUASI YAGI ANTENNA FOR CHANNEL MEASUREMENTS AT X BAND

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ABSTRACT

Uniplanar quasi yagi antenna has gained considerable attention recently as a method of producing a broad bandwidth antenna array with a well defined end-fire radiation pattern. An important advantage of the novel quasi-yagi antenna designed in x-band is its ability to be scaled linearly to any frequency band. This paper presents simulation results of scaled quasi-yagi antenna designed to operate around 10GHz using Agilent High frequency Structure Simulator (HFSS) software. Return loss, input impedance smith chart, radiation patterns, E-field, H-field and current distributions are simulated and presented.

Keywords: *Uniplanar, Quasi, X Band, HFSS, E-field, H-field*

1. INTRODUCTION

Microstrip patch antennas are increasing their demand due to its compactness. Currently used planar antennas such as microstsrip patch antenna are low cost and easy to fabricate but are inherently narrowband. Although there are many techniques that can be used to enhance the broadband design this comes at the expense of other antenna parameters. Such techniques can be obtained using multi-layer stacked configuration with aperture coupling patches or by introducing parasitic slots inside the patch. However, employing these techniques will increase the cost and add complexity to the system [1-3].

Although end-fire antenna arrays Vivaldi and other types of linearly tapered slot antenna can offer wider bandwidths than traditional microstrip antennas they have larger electrical size and are difficult to match over the en tire band using traditional feeds. This adds complexity, which causes the frequency response to be reduced.

The uniplanar quasi yagi antenna has been developed to give low cost, low weight and easy fabrication with broadband performance. The proposed antenna has low mutual coupling making it a popular candidate for phase arrays [4-6]. The planar antenna is a single layer printed dipole antenna fabricated on a low dielectric constant and is fed through a microstrip-to-coplanar strip transition and uses a truncated microstrip ground plane as a reflector. Important features of this antenna are its simple structure and capability of being linearly scaled to any frequency band.

The principle of operation of the uniplanar quasi-yagi antenna is reported in figure [1]. It utilizes a similar principle like a traditional yagi-uda dipole array [7-8]. In this design the ground plane is used as a reflector element he quasi yagi antenna with a director and driven element is printed on low permittivity substrate giving an end-fire radiation pattern. The truncated ground plane on the bottom of the substrate is act as a reflector element [9-12]. The antenna is small size and compact compared with Vivaldi and tapered slot line, end is fed by a standard microstrip line, which makes it easy for integration with other micro wave devices [13-15].

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This paper reports on the scaling of the X-band quasi antenna to produce a broad bandwidth antenna operating near 10GHz [16]. Agilent HFSS simulation is used to calculate the return loss, input impedance and the radiation patterns.

2. SINGLE ELEMENT ANTENNA STRUCTURE

Figure (1) shows the schematic diagram of the uniplanar quasi-yagi antenna. It consists of a printed dipole directed and a driver dipole fed by a broadband microstrip-to- coplanar strip transition. The overall dimension of this antenna is less than half wave length in size. The design parameters of the 10GHz X-band antenna given was scaled by a factor of 5 to realize the 10GHz band antenna assuming a single layer substrate. The characteristic impedance and the effective permittivity of the micro strip line were also to be the same and equal to 50Ω and 2.2, respectively. The antenna is fed from a conventional 50Ω. Coaxial connector through broadband microstsrip-to-coplanar strip transition. The dimensions of the proposed antenna are follows (unit in mm):$W_1=W_3=W_4=W_5=W_{dri}=W_{dir}=3$, $W_6=S5=S_6=1.5$, $L1=L_5=l=7.5$, $L_3=24$, $L_4=9$, $S_{ref}=19.5$, $S_{dir}=15$, $S_{sub}=7.5$, $L_{dri}=43.5$ and $L_{dir}=16.5$.

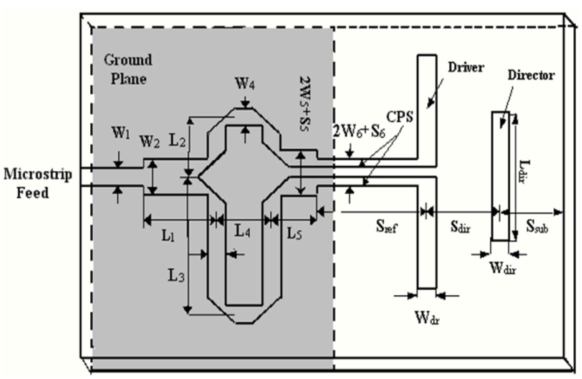

Figure (1) schematic diagram of uniplanar quasi yagi antenna

3. SIMULATION RESULTS AND DISCUSSION

The analysis and procedure is based on the full-wave electromagnetic solver based on Agilent HFSS simulator. The calculated (simulated) results for input return loss (amplitude and phase) against frequency area shown in figure (3). From the figure we notice the antenna provides a broad bandwidth of about 50 % for VSWR<2. The antenna as well matched and has a gain of about 5dB over more than 50 % bandwidth. Figure (5) shows the calculated input impedance of this broadband antenna. Figure (6) shows the far field radiation pattern in the E and H plane including the co-polarization and cross-polarization at 10GHz. The radiation pattern indicates a well-defined end fire with front to back ratio of more than 19dB and cross polarization level of better than 15dB. The simulated results of antenna radiation pattern show that radiation pattern is well stable over the operating band.

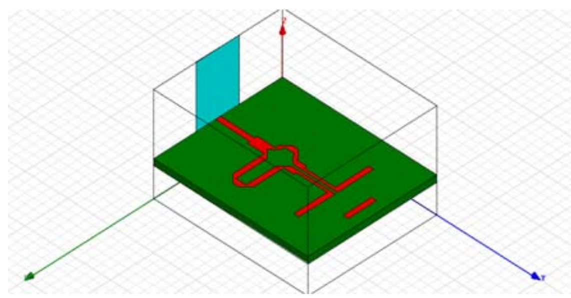

Figure (2) Ansoft model of quasi yagi antenna

Results and Discussion

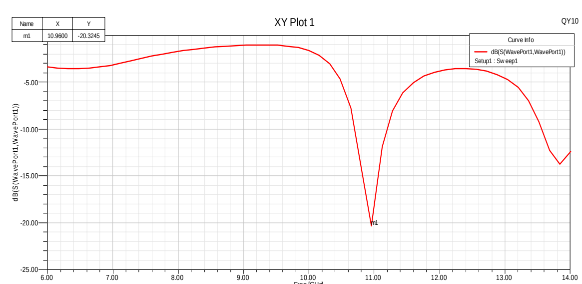

Figure (3) Return loss curve

The return loss value obtained for substrate material RT-duriod with dielectric constant 2.2 is -20.32dB. The value of return loss is in the acceptable range of <-10dB.

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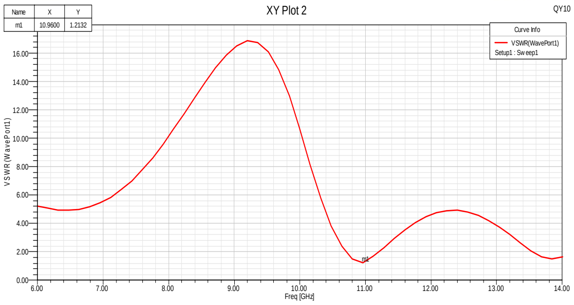

Figure (4) VSWR Vs Frequency

The VSWR<2 is obtained at the resonant frequency and the VSWR value obtained is 1.21.

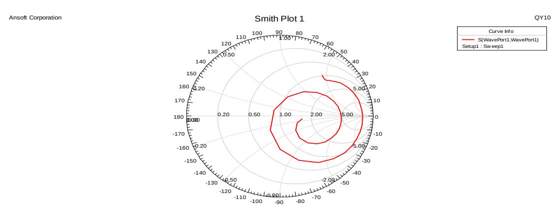

Figure (5) Input impedance smith chart

The parameters that are noted from the input impedance smith chart curve is tabulated and shown in the table (1).

Parameters simulated from Input impedance chart		
1	rms	0.677
2	Gain margin	17.36
3	Phase margin	227.90
4	Gain crossover	6
5	Phase crossover	10.88
6	Upper cutoff	6
7	Band width	6

Table (1) Input impedance smith chart parameters

The antenna radiation pattern or antenna pattern is defined as a mathematical function or graphical representation of the radiation properties of the antenna as a function of space coordinates. Radiation properties include power flux density, radiation intensity, field strength, directivity phase or polarization. In practice, the three dimensional pattern is measured and recorded in a series of two dimensional patterns. However for most practical applications, a few plots of the pattern as a function of θ for some particular values of φ, plus a few plots as a function of φ for some particular values of θ, give most of the useful and needed information.

The radiation of the antenna is expressed in terms of the field strength E(in V/m), and then the graphical representation is called field strength pattern or field radiation pattern. Similarly if the radiation of the antenna is expressed in terms of the power per unit solid angle, then the graphical representation is called power radiation pattern or power pattern.

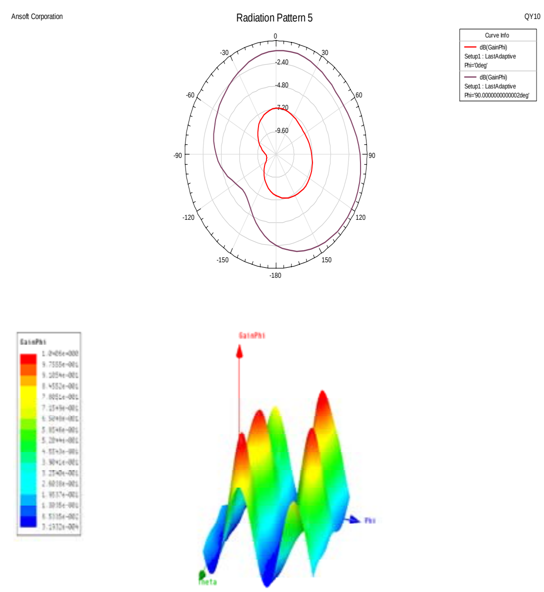

Figure (6) Polar and 3D pattern of gain-phi at 0^0 and 90^0

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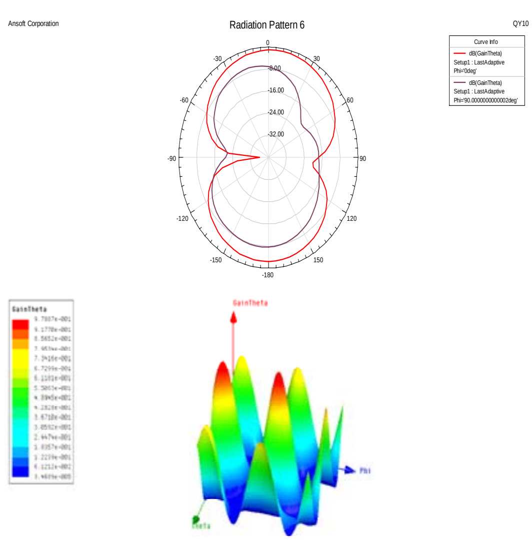

Figure (7) Polar and 3D patterns of gain-theta at 0^0 and 90^0

4. FIELD DISTRIBUTION

For horizontal antenna the Φ component of electric field as a function of Φ is measured in x-y plane ($\theta=90^0$). The field component can be represented as E_ϕ ($\theta=90^{0,}$ Φ) and it is called E-plane pattern. The Φ component of electric field as a function of Φ is measured in x-z plane ($\theta=0^0$). The field component can be represented as E_ϕ (θ, $\Phi=90^0$) and it is called H-plane pattern.

The 3D field distribution plots give the relationship between the co-polarization (desired) and cross-polarization (undesired) components. Moreover it gives a clear picture as to the nature of polarization of the fields propagating through the patch antenna. Figure (8) and (9) clearly shows the patch antenna E-field and H-field distribution.

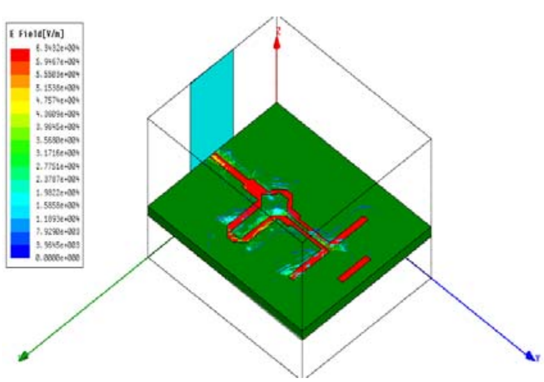

Figure (8) E-Field distribution

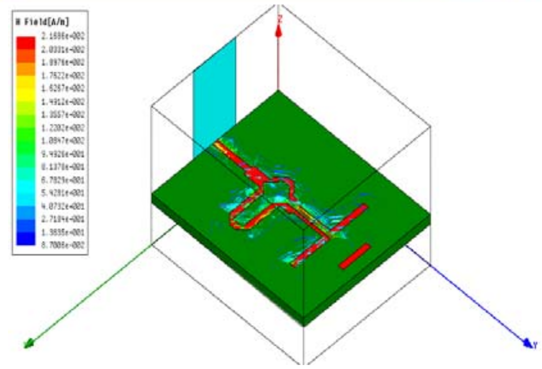

Figure (9) H-Field distribution

Mesh generation is the practice of generating a polygonal or polyhedral mesh that approximates a geometric domain to the highest possible degree of accuracy. The term "grid generation" is often used interchangeably. Typical uses are for rendering to a computer screen or for physical simulation such as finite element analysis or computational fluid dynamics. The triangulated zones in the mesh shown in figure (10) indicate the points in the grid where the current distributed is concentrated.

From the antenna parameters values of Peak Directivity, Peak Gain, Peak Realized Gain, Radiated power, Accepted power, Incident power, Radiation Efficiency, Front to back ratio, power and Radiation Efficiency, Decay factor, Max U values are obtained. From maximum field data table the values of rE field are obtained at angles Phi and Theta.

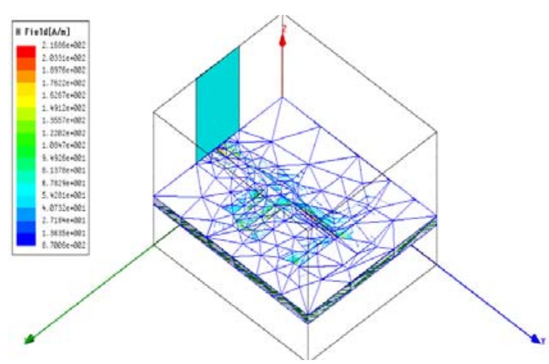

Figure (10) Mesh pattern

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Antenna parameters		
1	Max U	185.1 w/sr
2	Peak Directivity	51.796
3	Peak gain	51.17
4	Peak realized gain	23.26
5	Radiated power	44.90 w
6	Accepted power	45.45 w
7	Incident power	100 w
8	Radiation efficiency	0.988
9	Front to back ratio	1.4.4

Table (2) Antenna Parameters

Maximum field data values				
S.NO	rE field	Value (v)	At Phi (degrees)	At Theta (degrees)
1	Total	373.58	45	135
2	X	284	45	140
3	Y	102.3	40	140
4	Z	232.74	45	135
5	Phi	228.32	230	-45
6	Theta	329.15	45	-135
7	LHCP	214.19	45	40
8	RHCP	315.57	45	135
9	Ludwig3/X dominant	326.92	45	40
10	Ludwig 3/Y dominant	350.94	230	-135

Table (3) Maximum field data

5. CONCLUSION

A uniplanar quasi-yagi wideband antenna operating near 10GHz realized on thick substrate with low dielectric constant is successfully demonstrated using Agilent HFSS simulation. The antenna has a simple structure, compact and easy to fabricate. It provides a well-defined end-fire antenna, which makes it well suited for use in base stations of wireless communication systems, electronically steering phased arrays and power combining application.

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