Broadband and Compact Quasi-Yagi Antenna for High frequencies

Anthadapula Srujana, Nirmala Yerpula

Abstract— **In this paper, a compact, broadband quasi-Yagi antenna utilizing ultra-wideband MS-to-CPS balun has been introduced. The formed bottom ground plane is a reflector and helps to reduce the antenna size by fifty three of the previous style. It conjointly helps to scale back EM interactions between the reflector and also the Hz feed; thereby, the look is scalable to mm-wave frequencies. The MS-to-CPS balun provides wonderful part and amplitude balances for the operational bandwidth. The measured radiation patterns show terribly similar performances for the entire operating waveband. The planned antenna are often a cheap resolution for numerous compact, broadband phased arrays and imaging systems for microwave/mm-wave frequencies.**

Index Terms— **quasi-Yagi antenna, microstrip, balun, radiation efficiency, radiation pattern, antenna gain.**

I. INTRODUCTION

Simple coplanar quasi-Yagi antennas[1] have wide been employed in microwave/mm-wave wireless systems thanks to their broad information measure, good gain, low cost, easy fabrication, and easy integration with microwave integrated circuits (MICs). Many varieties of style for the coplanar quasi-Yagi antennas are reported for numerous applications like phased arrays, power combining, and active arrays[1]-[7]. The driving force dipole component was used in the main to excite the TE-mode surface wave. The truncated small strip ground plane acted as a reflective component for the surface wave, leading to forward-directed radiation. With these antennas, the styles of the antenna diverging elements were similar, however the most variations song at the antenna feeding networks. The antenna feeding structures are balun structures to rework the conductor mode at the antenna input to the two-dimensional strip line (CPS). Samples of numerous feeding structures used for the quasi-Yagi antennas are MS-to-CPS Balun (or transition) in[1][2], two-dimensional wave guide.

Nowadays, quasi-Yagi antenna is wide utilized in wireless communication for its high directionality, high radiation potency, low cost, low profile, also as straightforward to fabrication but, the most disadvantage of those antennas is slim information measure and therefore the information measure usually achieves simply 100%. to unravel this drawback, researchers have created nice efforts to boost the band- dimension of Yagi aerial antenna victimization many ways.

Many completely different techniques are planned in literature, regarding the improvement of electric resistance band- dimension in small strip antennas, principally by increasing the substrate thickness, by decreasing the substrate material constant and by different feeding ways (aperture coupled or proximity rather than direct contacting feed). Moreover, by increasing the dimension of the written dipole antennas, the information measure of antenna will increase. By victimization triangular rather than rectangular dipole arms (bow-tie-configuration), the information measure may be additional dilated to thirty seventh as bestowed by Bailey. Two-dimensional parasitic parts are planned by Deal in an exceedingly quasi-Yagi configuration, yielding associate electric resistance information measure of forty eight.

Where one half the antenna; dipole or bow-tie, is written on the highest substrate layer and connected to the small strip feed line, whereas the last half is placed on rock bottom substrate layer and connected to the bottom plane. Doing that avoids victimization balun[6] and simplifies antenna pure mathematics. additionally, one will get endfire radiation patterns of excellent front-to-back magnitude relation out of those styles Wide bandwidths of four-hundredth, five hundredth and ninety one ar obtained severally. the steadiness of the patterns during this style depends on the substrate height and also the resonator itself. If the substrate height is massive relative to the free house wavelength (λ0) at the higher in operation frequency, unstable patterns are obtained at higher frequencies, which ends up in decreasing the usable information measure of the antenna. Also, if the antenna has just one main resonance at the in operation band, distorted pattern is predicted at high frequencies, wherever the antenna size is far larger than (λg/2). Such issues are often resolved by victimization antennas with little substrate height, and multi-resonators, wherever every resonator preserves pattern stability around its resonant frequency.

The microstrip-fed quasi-Yagi antenna[5] is predicated on the Yagi-Uda antenna[1]-[7], firstly conferred in 1928. The quasi-Yagi associate degreetenna consists of a 0.5 wavelength dipole and an or so quarter wavelength rectangular director to extend the gain and improve the front-to-back magnitude relation. This antenna exhibits a lot of smaller size than the bureau. an outsized operational information measure of forty eighth for VSWR < a pair of was incontestible within the X band. By exchange the dipole and also the director of the quasi- Yagi aerial antenna by a bow-tie the information measure improved to hour, and also the antenna size was reduced two hundredth. Additional analysis resulted in a very novel microstrip-fed[1]-[3] written antenna, referred to as written Lotus antenna, with a modified balun. The written Lotus provides fifty seven information

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***Anthadapula Srujana**, Department of ECE, K.L.R College of Engineering and Technology Khammam, India, Mobile No:+91-9640518604.*

***Dasari Neelima**, Department of ECE, K.L.R College of Engineering and Technology Khammam, India, Mobile No: +91-9640518604.*

measure for VSWR < 1.5, and hour relative to VSWR < 2. However, the balun in these styles is predicated on a 0.5 wavelength ($\lambda g/2$) electric circuit, That is meant at the middle frequency (fc). This slim band electric circuit limits the information measure of the antenna. Additionally, the radiation patterns are deteriorated as frequency goes means from fc, particularly within the E-plane.

An identical Yagi aerial like double sided antenna, achieved an information measure of thirty seventh. Stacked parasitic components (aperture attacked patches) ar wide used for increased information measure, however their fabrication is comparatively difficult and pricey. To boot, a broad-band quasi-Yagi antenna achieving a measured forty eighth band- dimension is conferred for measuring system systems and millimeter-wave imaging arrays. we've got conferred few year past in a very multi-band frequency written dipole with operation at a pair of.45, 5.8 and ten gigahertz.

First, the look construct of the projected written dipole with reflector (with lowest quality design). A parasitic part is embedded to extend the information measure of antenna. Finally, the written dipole with a 3 parasitic components is studied to change the operation of broadband. The antennas are designed and with success measured.

The quality of feeding structures typically will increase style factors and so optimisation time, however conjointly as such limits the frequency information measure of the driven part. so as to get the specified information measure and gain from the antenna, with associate degree EM machine, a major quantity of simulation time would be needed to tune and optimize the antenna parameters. Moreover, amplitude and part imbalances on the Hz feed lines weren't investigated in previous styles of broadband quasi-Yagi antennas[10].

II. LITERATURE SURVEY

The first antennas were built in 1888 by German physicist Heinrich Hertz in his pioneering experiments to prove the existence of electromagnetic waves predicted by the theory of James Clerk Maxwell. Hertz placed dipole antennas at the focal point of parabolic reflectors for both transmitting and receiving. The origin of the word antenna relative to wireless apparatus is attributed to Italian radio pioneer Guglielmo Marconi. In 1895, while testing early radio apparatus in the Swiss Alps at Salvan, Switzerland in the Mont Blanc region, Marconi experimented with long wire "aerials". He used a 2.5 meter vertical pole, with a wire attached to the top running down to the transmitter, as a radiating and receiving aerial element.

Compact and Broadband Quasi-Yagi Antenna for X- to Ku-band Applications including balun and transformer for impedance matching. In many of the reported design approaches, there were no explicit guidelines suggested for performing impedance matching between the CPS line and the input microstrip transmission lines. In addition, in the design of most commonly used MS-to-CPS balun[9] structures for the quasi-Yagi antenna suggested [7][8],180 degree phase difference on the CPS lines was guaranteed only for narrow bandwidth near the center frequency; i.e., the odd-mode conversion with the phase delayed leg was expected to work only for narrow frequency bandwidth. Also, most of the broadband quasi-Yagi antenna[4] designs were mainly based on return loss performances. Broad impedance bandwidth, of course, is a necessary requirement for the broadband antennas, but may not be a sufficient criterion for good radiation characteristics for whole frequency band. A brief history of antenna evolution is as follows

➢ Yagi-Uda antennas	1920s
➢ Horn antennas	1939
➢ Antenna arrays	1940s
➢ Parabolic reflectors	late 1940s and early 1950s
➢ Patch antennas	1970s
➢ PIFA	1980s

III. THEORETICAL ANALYSIS

The theoretical analysis of basic rectangular patch antenna structure, theoretical formulas and calculations required in designing E-shape microstrip patch antenna.

A. Microstrip Patch Antenna Structure

A microstrip patch antenna (MPA) consists of a conducting patch of any non-planar or planate pure mathematics on one facet of a nonconductor substrate and a ground plane on different facet. it's a written resonant antenna for narrow-band microwave wireless links requiring semi-hemispherical coverage. Attributable to its planate configuration and simple integration with microstrip technology, the microstrip patch antenna has been wide used. The oblong and circular patches ar the essential and most typically used microstrip antennas.

The Fig 3.1 shows a microstrip patch antenna with a nonconductor substrate mounted on a ground plane. The nonconductor substrate is of thickness (h). The patch is mounted on the nonconductor substrate with nonconductor constant or permittivity (∈_r). The patch is of length (l), dimension (w) and thickness (t). In our design we tend to use microstrip printing operation. The microstrip patch with microstrip feed a is shown in the Fig 3.2.

In the Fig 3.2, a conducting strip is connected on to the sting of the microstrip patch. thus it's a microstrip feed. The normally used substrates are FR-4 substrate and RT DUROID 5880 substrates.

The frequency of operation of the patch antenna of Figure 3.1 is determined by the length L. The center frequency will be approximately given by:

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}} = \frac{1}{2L\sqrt{\varepsilon_0 \varepsilon_r \mu_0}}$$

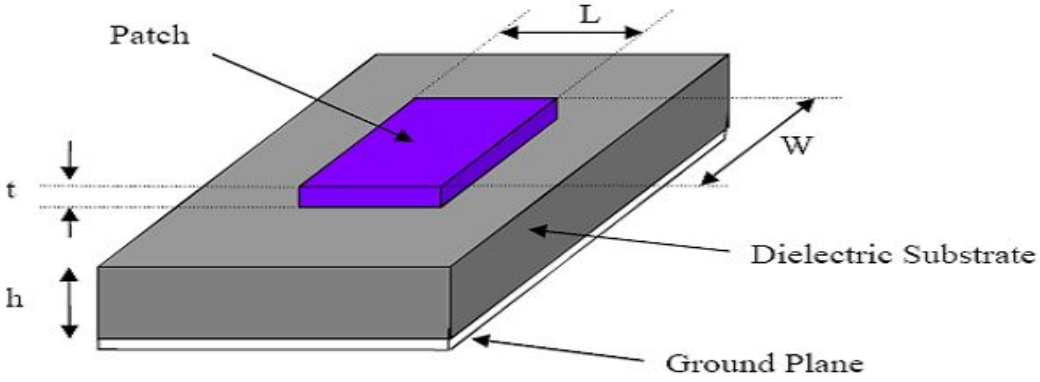


Fig. 3.1: Microstrip Patch Antenna Configuration

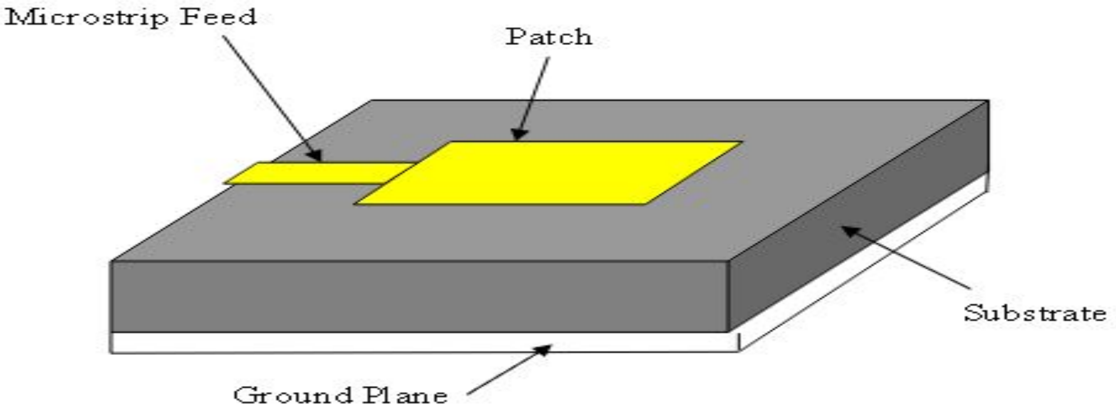


Fig. 3.2: Microstrip Antenna With Microstrip Feed

The above equation equation shows that the microstrip antenna ought to have a length adequate to one half a wavelength at intervals the nonconductor (substrate) medium. The dimension W of the microstrip antenna controls the input ohmic resistance. Larger widths can also increase the information measure. For a sq. patch antenna fed within the manner higher than, the input ohmic resistance are going to be on the order of three hundred Ohms. By increasing the dimension, the ohmic resistance will be reduced. However, to decrease the input ohmic resistance to fifty Ohms typically needs a really wide patch antenna, that takes up plenty of valuable house. The dimension any controls the radiation diagram. The fields of the microstrip antenna ar planned in Figure3.3 for W=L=0.5λ.

B. Theoretical Values And Calculations

To calculate the dimensions of E-shape microstrip patch antenna, the following theoretical values and formulas are required

1) The width of the patch element (W) is given by

$$W = \frac{c}{2 f_0 \sqrt{\frac{\varepsilon_r + 1}{2}}}$$

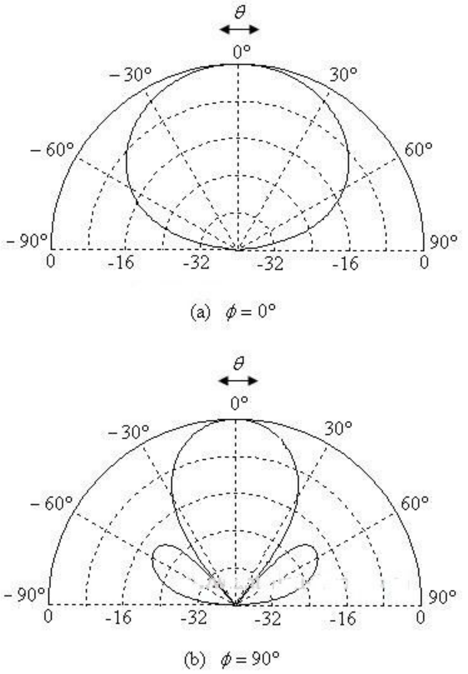
Where W is the width of patch element

c is the velocity of light= $3x10^8$ m/s

f_0 is the optimum frequency = 5 GHz

Substituting c = $3x10^8$ m/s, ε r = 2.2, and fo = 5 GHz, then

W =2.3717cm or 933.74 mile.



(a) $\phi = 0°$

(b) $\phi = 90°$

Figure 3.3: Normalized Radiation Pattern for Microstrip (Patch) Antenna

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2) The effective of the dielectric constant (εreff) depending on the same geometry (W, h) but is surrounded by a homogeneous dielectric of effective permittivity εreff, whose value is determined by evaluating the capacitance of the fringing field.

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{W}]^{0.5}$$

Substituting εr = 2.2, W =2.3717cm, and h =0.1575cm, then εreff = 2.1074cm or 829.69mile

3) The effective length (L eff) is given by

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}}$$

Substituting, c = 3x10^8 m/s. εreff = 2.0475cm, and f_0 = 5GHz, then

Leff = 2.0665cm or 813.6 mile

4) The length extension (ΔL) is given by:

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)}$$

Substituting εreff = 2.1074cm, W =2.3717cm, and h =0.0787cm, then ΔL= 0.041469cm or 16.3266mile.

5) The actual length (L) of patch is obtained by

$$L = L_{eff} - 2\Delta L$$

The design of E-shape microstrip antenna is as follows

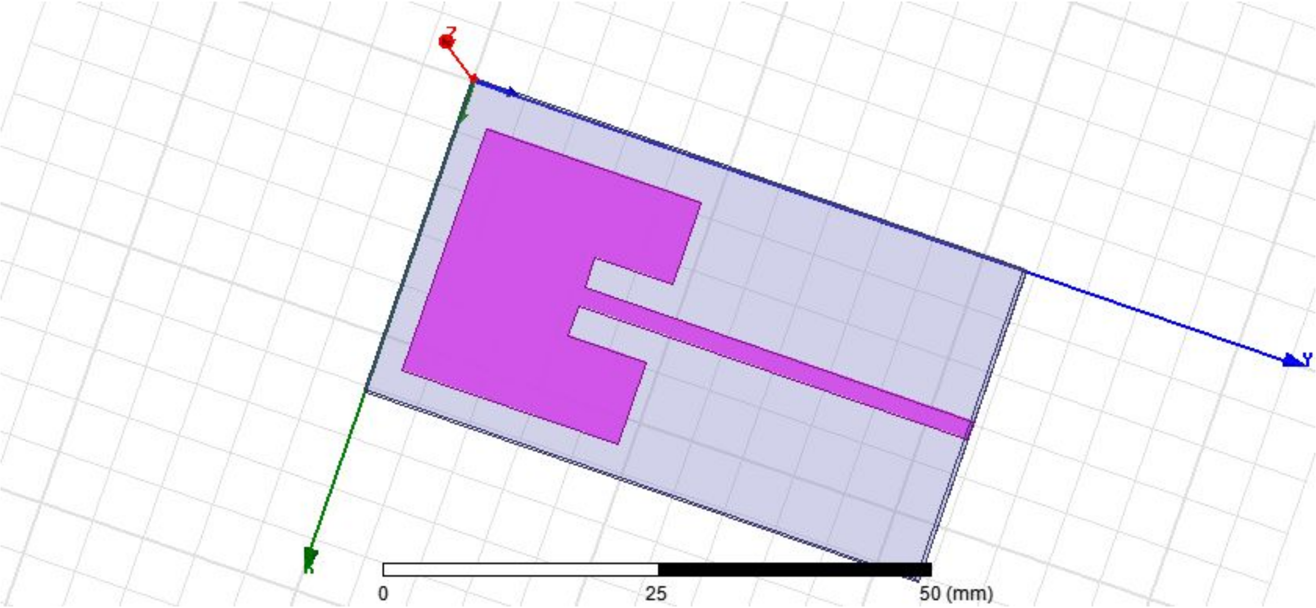


Figure 3.4: Design of E-Shape Microstrip Patch Antenna

In the above Fig 3.4, we use RT-DUROID 5880 substrate as dielectric. In this theme, every node with message searches for potential path nodes to repeat its message. Hence, potential path nodes of a node ar thought of. Using NSS, every node having message selects its path nodes to produce a adequate level of end-to-end latency whereas examining its transmission effort. Here, it derives the CSS live to allow CR-Networks nodes to choose that authorised channels ought to be used. The aim of CSS is to maximise spectrum utilization with minimum interference to primary system. Assume that there are M authorised channels with completely different information measure values and y denotes the information measure of channel c. every CR-Networks node is additionally assumed to sporadically sense a collection of M authorised channels. Mi denotes the set together with Ids of authorised channels that ar sporadically detected by node i. suppose that channel c is sporadically detected by node i in every slot and channel c is idle throughout the quantity x known as channel idle length. Here, it use the merchandise of channel information measure y and also the channel idle length x, tc = xy, as a metric to look at the channel idleness. Moreover, failures within the sensing of primary users ar assumed to cause the collisions among the transmissions of primary users and CR-Networks nodes.

IV. DESIGN ANALYSIS

The design of the structure relies on the theoretical calculations mentioned within the previous chapter. the planning is finished in 2 simulation soft wares specifically Central Time (COMPUTER SIMULATION TECHNOLOGY) and HFSS (HIGH FREQUENCY STRUCTURE SIMULATOR). Central Time and HFSS area unit magnetism simulators employed in the planning and analysis of high frequency (HF) devices like antennas, filters, couplers, plate like and multi-layer structures and SI and EMC effects.

A. style Simulator –CST Studio Suite

CST - theoretical account Technology Ag (CST) could be a German software package company with headquarters in Darmstadt. the most product of Central Time is Central Time STUDIO SUITE, that contains numerous modules dedicated to specific application areas. There area unit modules for microwave & RF applications, summarized in Central Time MICORWAVE STUDIO, low frequency (CST EM STUDIO), PCBs and packages (CST PCB STUDIO), cable harnesses (CST CABLE STUDIO), temperature and mechanical stress (CST MPHYSICS STUDIO) and for the simulation of the interaction of charged particles and magnetism fields (CST PARTICLE STUDIO). All modules area unit integrated with a system gate machine (CST style STUDIO).

In design we tend to use CST MICROWAVE STUDIO (CST MWS). CST MICROWAVE STUDIO® (CST MWS) may be a specialist tool for the 3D EM simulation of high frequency elements. CST MWS' alone performance makes it initial alternative in technology leading R&D departments. CST MWS permits the quick and correct analysis of high frequency (HF) devices like antennas, filters, couplers, planar and multi-layer structures and SI and EMC effects. Exceptionally user friendly, CST MWS quickly provides associate degree insight into the EM behavior of high frequency styles.

B. Design Process in CST

For coming up with the desired form in CST MICROWAVE STUDIO (CST MWS).the following steps square measure followed.

1. Open CST STUDIO SUITE and so click on CST MICROWAVE STUDIO (CST MWS).
2. Because the needed style is planar, choose planar form from the essential shapes given.
3. Choose brick form and assign X, Y and Z co-ordinates thereto PRN per the look. This can be the bottom plane. X & Y co-ordinates denote the length and breadth of the bottom plane severally. Z denotes the thickness. Choose the fabric as PEC (Perfect electric).
4. Then choose solid two and assign X1, Y1 co-ordinates thereto same as that of the bottom
5. Plane. Z2 is varied .This is the di-electric substrate RT DUROID 5880.The thickness(Z2) of di-electric substrate is varied in our style and simulation results square measure allotted .
6. Then choose solid three and co-ordinates thereto .This the patch.
7. Choose solid and assign X4, Y4 co-ordinates thereto. These square measure the cut breadth and cut depth of the antenna. Cypher it from solid three.We get a cut-shape piece (Boolean subtract).
8. Choose another solid and assign X5, Y5 co-ordinates. These square measure the strip patch length and strip patch breadth severally. Add it to solid three (Boolean add).
9. This completes the look of the structure. Then head to fast begin guide and assign frequencies, boundary conditions, wave guide ports etc needed as per the look.
10. Begin the transient convergent thinker and see the simulation results.
11. Return loss (S11) and VSWR square measure calculated for various substrate thickness (Z2) and simulation results square measure noted down.

C. Design Simulator –HFSS

HFSS may be a industrial finite part methodology convergent thinker for magnetic attraction structures from Analysis. The descriptor originally stood for top frequency structural machine. it's one amongst many industrial tools used for antenna style, and therefore the style of complicated RF electronic circuit components as well as filters, transmission lines, and packaging. it had been originally developed by prof Zoltan Cendes and his students at Carnegie altruist University.

HFSS is that the industry-standard simulation tool for 3D full-wave magnetic attraction field simulation. HFSS provides E- and H-fields, currents, S-parameters and close to and much radiated field results. Intrinsic to the success of HFSS as associate degree engineering style tool is its machine-controlled answer method wherever users square measure solely needed to specify pure mathematics, material properties and therefore the desired output. From here HFSS can mechanically generate associate degree applicable, economical and correct mesh for determination the matter.

D. Design Process in HFSS

1. Open HFSS software package.
2. Choose insert HFSS style and draw rectangle1 .This is ground plane. All x,y and z dimensions square measure unbroken in mil.
3. Then draw box1 that is nonconductor with thickness .Assign x,y and z co-ordinates.
4. Then draw rectangle2 that is patch. Assign x,y and z co-ordinates.
5. Then draw parallelogram3 with completely different centre and cypher it from rectangle two. Assign x,y and z co-ordinates.
6. Draw rectangle4 and assign x,y and z co-ordinates. This offers the strip path length and strip path breadth.
7. Then draw box2 that is that the radiation box. Choose wave guide port and provides excitation.
8. Begin the convergent thinker and see the simulation results. The substrate thickness is varied and simulations square measure allotted for various substrate thickness

V. RESULTS

A. Structure in CST/HFSS:

The Figure 5.1 shows the structure in CST/HFSS

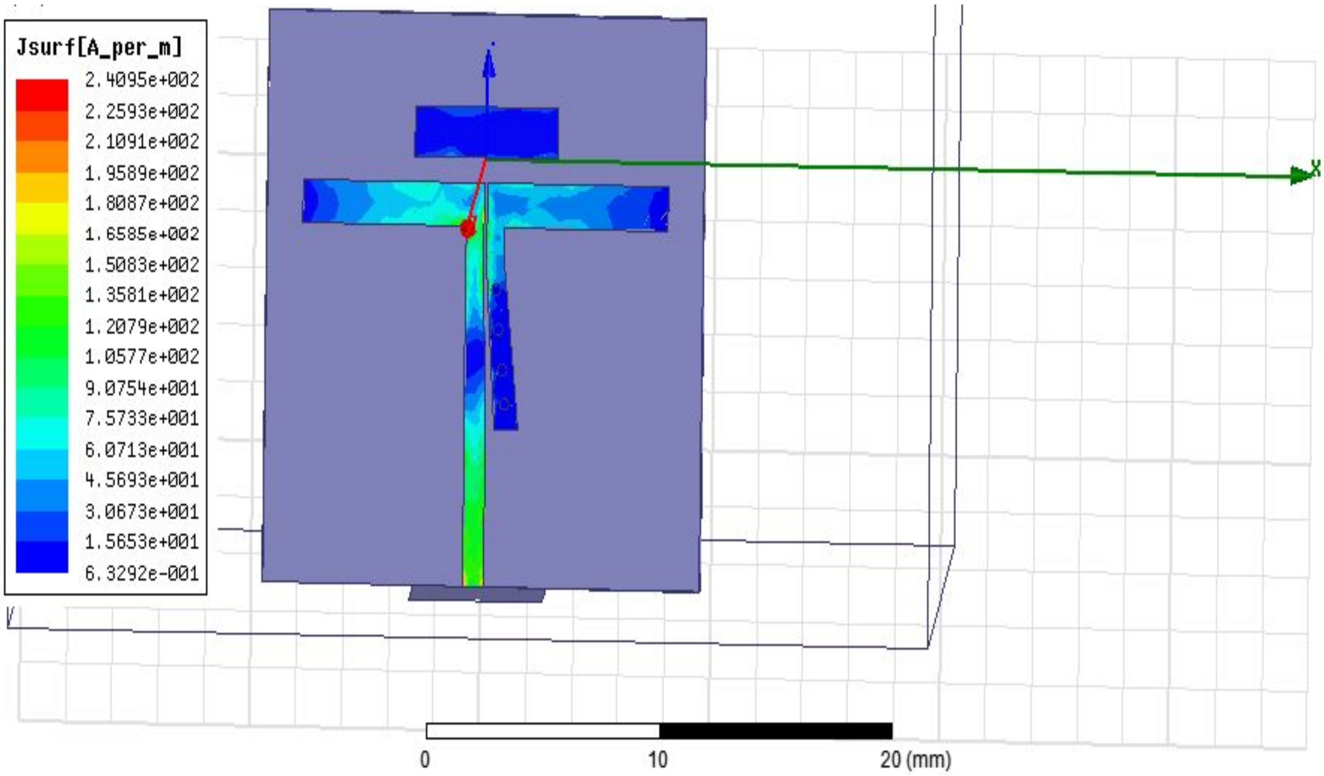


Fig.5.1 Structure in CST/HFSS

B. Results in CST/HFSS

The results in CST/HFSS shown in the Figure 5.2, S11 parameters shown in the Figure 5.2 (a) radiation pattern shown in the Figure 5.2 (b), gain shown in the Figure 5.2(c), Gain phi 90 varying theta shown in the Figure 5.2(d), VSWR shown in the Figure 5.2(e).

5.2.1 S11 parameters:

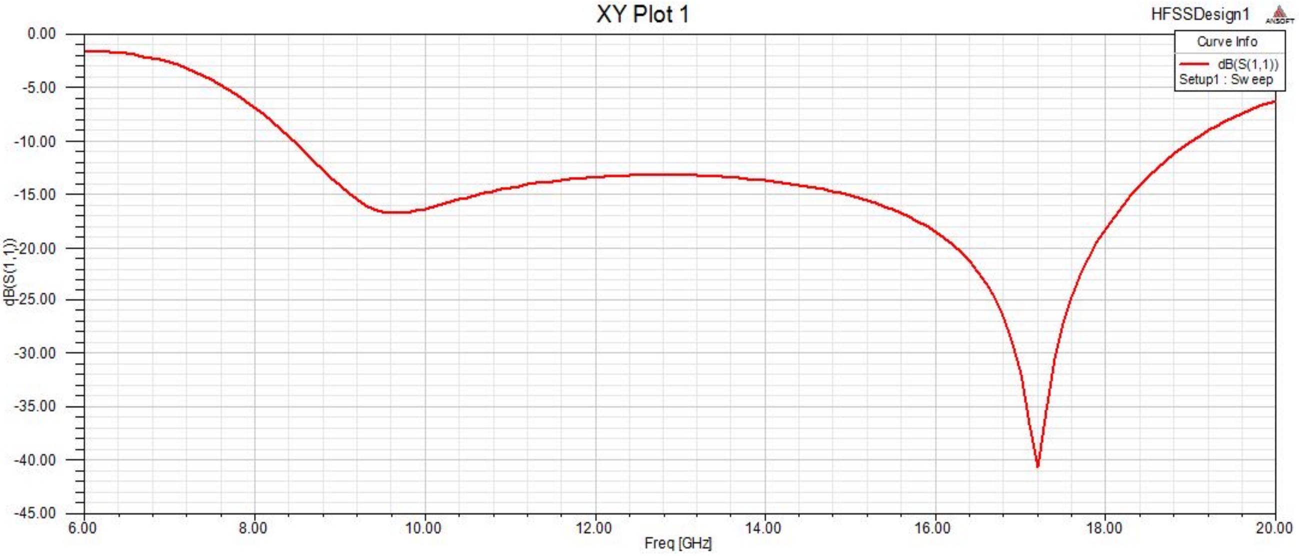


Figure 5.2.1 : S11 parameters

5.2.2 Radiation Pattern :

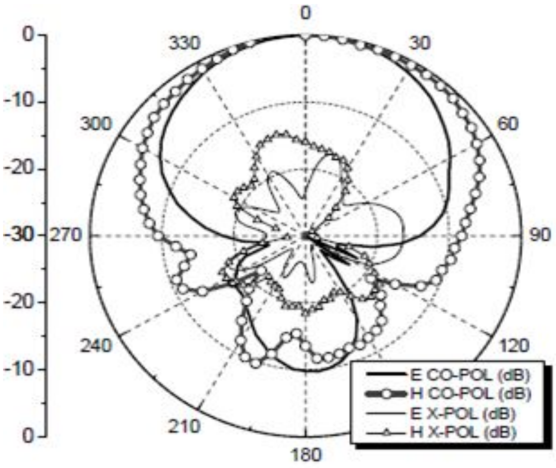


Figure 5.2.2: Radiation Pattern

5.2.3 Gain :

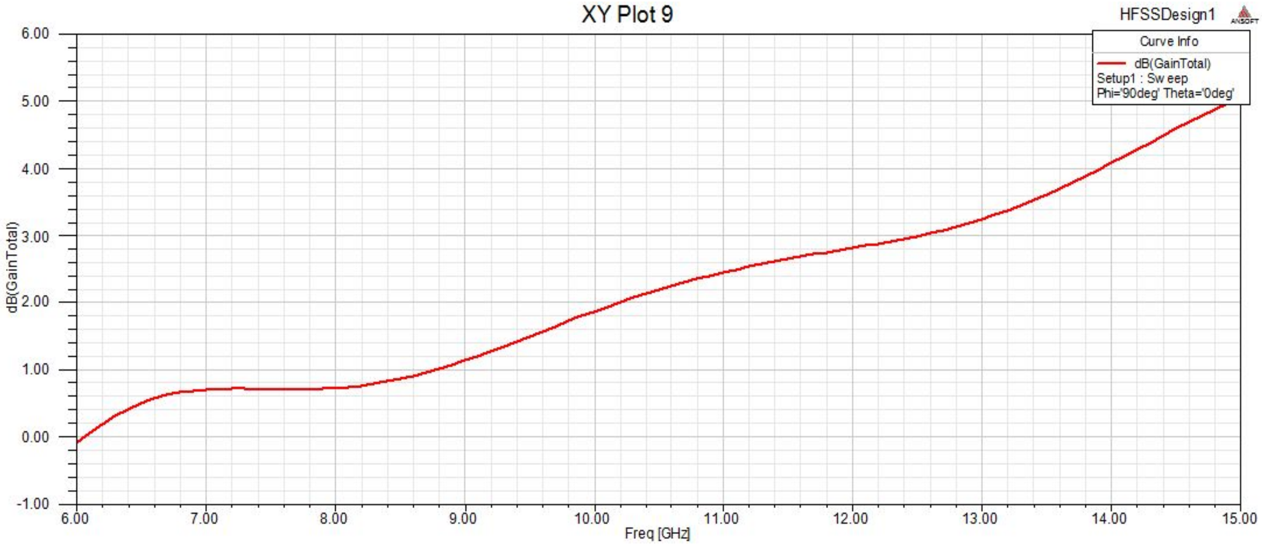


Figure 5.2.3: gain vs frequency

5.2.4 Gain phi 90 varying theta:

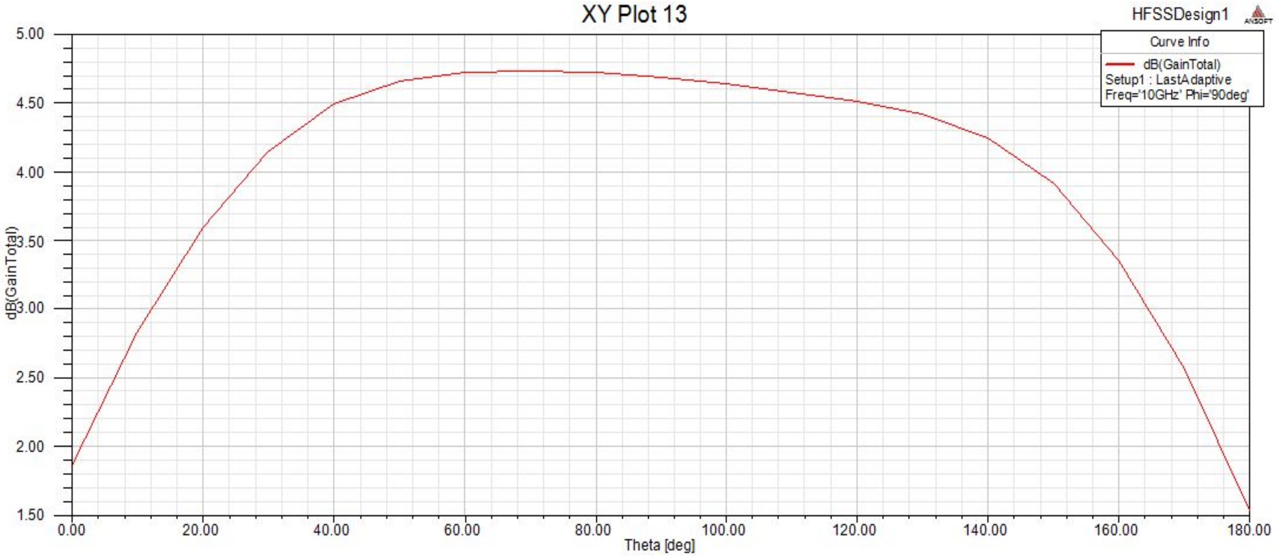
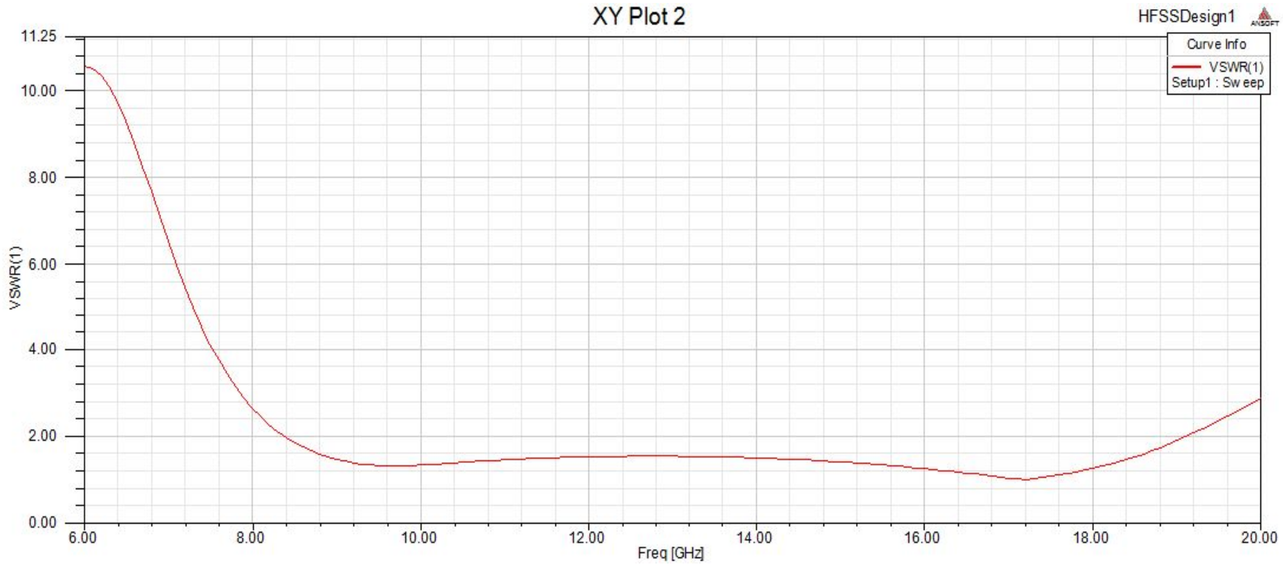


Figure 5.2.4: gain phi 90 varying theta

5.2.5 Voltage Standing Wave Ratio



(e) Voltage Standing Wave Ratio
Figure 5.2 results in CST/HFSS

VI. CONCLUSION

A compact, broadband quasi-Yagi antenna utilizing ultra-wideband MS-to-CPS balun has been introduced. The formed bottom ground plane is a reflector and helps to cut back the antenna size by fifty three of the previous style. It conjointly helps to cut back EM interactions between the reflector and also the Hertz feed; thereby, the planning is ascendible to mm-wave frequencies. The MS-to-CPS balun provides glorious part and amplitude balances for the operational information measure. The measured radiation patterns show terribly similar performances for the total operational waveband. The projected antenna are often an economical answer for varied compact, broadband phased arrays and imaging systems for microwave/mm-wave frequencies.

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