Plan and Simulation Yagi Micro-Strip Antenna for 10GHz Applications

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Abstract. This paper shows a micro-strip antenna based on the yagi antenna principle, both singly and in a matrix. The suggested antenna can operate at a frequency of 10 GHz, which is in the X-band, That suggested a return loss (S11) should be lessthan (-10 dB) and"the Voltage Stand Wave Ratio"(VSWR) should be lessthan 2. Two types of micro-strip Yagi antennas were simulated and compared by calculating the parameters (directivity, gain, parameter S11, VSWR). The first design consists of one antenna and the second consists of a group of two antennas. CST Microwave studio soft-ware 2019 was used for designing and simulation. The results were for antennas constructed for Gain (5.308dB) (9.682dB) and Directivity (6.016dB) (10.28), with the second Antenna outperforming the first antenna by a wide margin.

Keywords: Micro-strip, Patch, Yagi, Directivity and Gain.

Introduction

Antennas are one of the most important components in various communication bands [1]. On the insulator substrate, the radiating components and normally feeding lines are photo etched [2]. The radiating patch could be any shape, including square, rectangle, thin strip, circular, elliptical, triangle, and so on. Printed Micro-strip antennas are widely used in applications due to their low profile, light weight, low cost, and high efficiency [3, 4]. To achieve directivity and gain, shorting walls, tailored slots, and electromagnetically connected patches were used, whereas parasitic patches or high permittivity substrates were used to create higher directivities [5, 6, 7]. Huang proposed for portable satellite applications, a Yagi antenna is used in micro strip technology in 1989, which demanded a low-cost, low-profile antenna with a 40-beam-width coverage [8]. Antenna components are divided into two categories: driven and parasitic (non-driven). The driven component has a direct connection to the transmission line and receives power from or is driven by the source. Non-driven components get energy entirely through mutual induction with a driven or parasitic component because they are not connected to the transmission line [9]. A reflector is a non-driven component that is longer than the driving component from which it obtains power [10]. The signal strength was reduced by a reflector, but it was increased in the opposite direction [11]. As a result, it could've been a sunken mirror. The term "director" refers to a parasitic component that has more limitations than its driven counterpart. A director is typically used to increase strength of the field in one direction while decreasing it in the other direction. As a result, it could have been a convergent convex lens [12, 13]. The main aim of this paper is to create a design and simulate single and array Yagi Micro-Strip Patch Antennas, and compare the Radiation characteristics of Directivity and Gain between them.

Methedology

Figure (1) illustrates the suggested Yagi antenna construction. A reflector, micro-strip patch, micro-strip feed line, which is a driven component, and one director make up the plan. The micro-strip Yagi antenna is excited through the driven patch along with a feed line [14, 15]. The standard of the patch length and width are determined by using formulas (Eq1, Eq2, Eq3, Eq4 Eq5) in table 1. Yagi antennas are directional, that is allow a concentration of energy in a certain direction, the parasitic components that make up the antenna allow to increase the directivity and therefore the gain, these components are known as directors, and the reflector component allows the energy that is transmitted on the back of the antenna to be reflected forward [16, 17, 18]. The director and reflector components will be planed based on equations (Eq6, Eq7, Eq8) in table 1. The plans are simulated using CST STUDIO SUITE 2019. By modifying the length, width, and spacing between the components, various antenna parameters are analyzed. The antenna will be planed considering an operating frequency of 10 GHz.

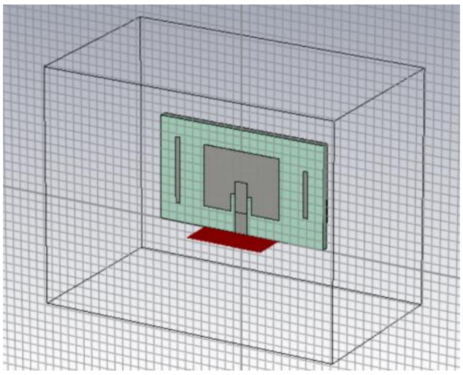


Figure1:Yagi Micro-strip antenna

Table 1. Yagi Micro-strip Antenna Parameters

Parameter	apprivation	Math Epression	Equation No.
Width	W	$w = \frac{c}{2fr}\sqrt{\frac{2}{(\epsilon r+1)}}$	Eq1
The effective dielectric constant	ϵeff	$\varepsilon eff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon}{}$	Eq2
extension length	ΔL	$\Delta L = 0.412\frac{(\varepsilon eff}{(\varepsilon eff}$	Eq3
effective length	Leff	$Leff = \frac{c}{2fr\sqrt{\varepsilon eff}}$	Eq4
Length	L	$L = Leff - 2\Delta L$	Eq5
Director Length	Dir	0.4 to 0.45λ	Eq6
Reflector Length	Ref	0.495 λ	Eq7
separation	Sep	0.25 λ to 0.4λ	Eq8

Simulation and Plan of Single Yagi Micro-Strip Antenna

To start with, the single patch square shape, the patch’s length and width were determined as 6.955mm and 9.208mm, individually, for a working frequency of 10 GHz utilizing a square patch plan condition [12]. The single patch component's characteristics were significantly leveraged to Lp =6.985mm and Wp=9.246mm. The overall antenna's parameter suggested are Lp=11.785mm and Wp=20mm with a micro-strip patch thickness of h=0.8mm. The plan was created on a FR-4 substrate with a dielectric constant ϵr=4.3. As shown in Figure 1, an inset of size 2 mm 0.55 mm was constructed on either side of the rectangle patch in the plan. The inclusion of insets to the patch assisted in reaching a 10 GHz operational frequency band. To improve the directivity and gain, Yagi components were added to the design. . On the left side of the patch, a reflector component was installed, and on the right side, a director component was inserted. To get the desired effects, the distance between the director and reflector components to patch was changed. Table 2 shows the dimensions lists of the finished single patch component with Yagi components.

Table 2. Dimensions of the single patch component

Components	Parameters	mm
Patch	L*W	6.985*9.246
Height	h	0.8
Patch thin	t	0.035
Substrate	Ls*Ws	11.785*20
Ground	Lg*Wg	11.785*20
Feedline	Lf*Wf	4.4*1.43
Insets	Lins*Wins	2*0.55
Director	Ld*Wd	5.25*0.5
Reflector	Lr*Wr	7.5*0.5

As in the previous method, the antenna will be planed with up to one reflector and one director components, each director and reflector components separated by a certain distance from the patch component, The S parameters shown in Figure 2 represent the frequency at which the single Yagi micro-strip antenna, in this case 10 GHz, measurements in figures (2-5) respectively the return-loss, VSWR, Directivity and Gain results (-35dB, 1.03615, 6.016dB and 5.308dB) respectively.

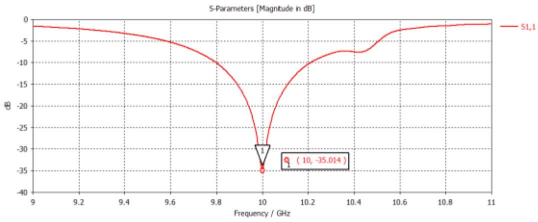


Figure2: S11-parameters for Single Yagi Micro-Strip Antenna

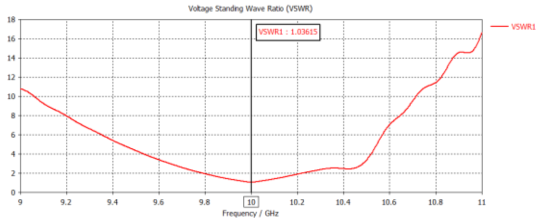
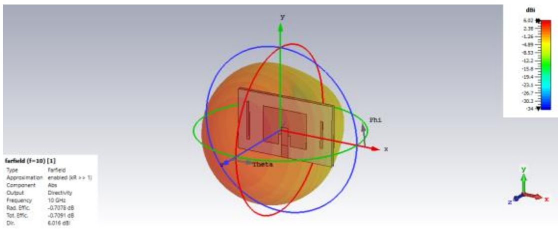


Figure3: VSWR for Single Yagi Micro-Strip Antenna



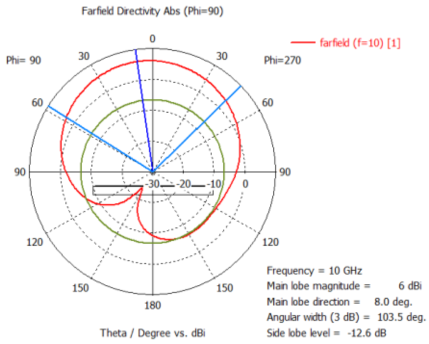
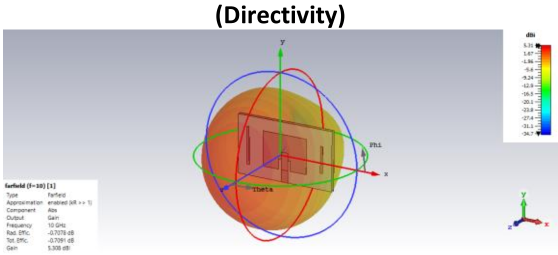


Figure4: Farfeild for Yagi Micro-Strip Antenna (Directivity)



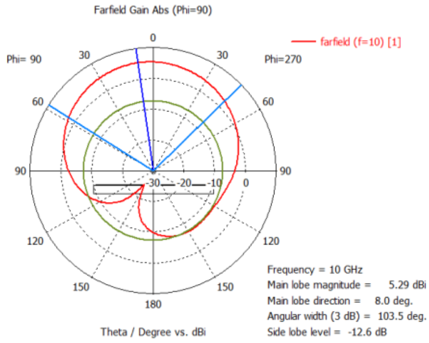


Figure5: Farfeild for Yagi Micro-Strip Antenna (Gain)

Plan & Simulation of the array Yagi Micro-Strip Antenna

Following the planning of a single patch component that met the required antenna performance, the patch components were joined to construct a two-component antenna as shown in Figure 6. There are two branches to the proposed micro-strip Yagi antenna design. This design is based on one branch's micro-strip Yagi antenna. The improved Directivity and Gain are the key advantages of this arrangement over a single branch structure. As shown in the figures (7-10) respectively the return-loss, VSWR, Directivity and Gain results (-29.936dB, 1.0658, 10.28dB and 9.682).

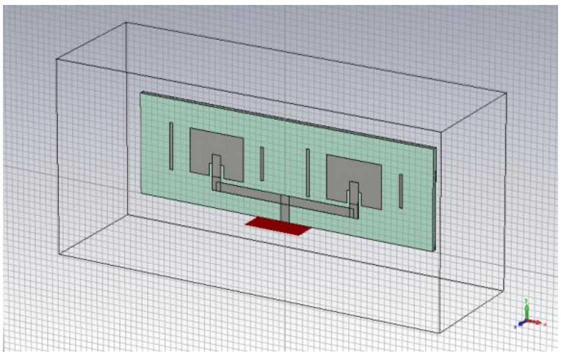


Figure6: Yagi Array Micro-Strip Antenna plan

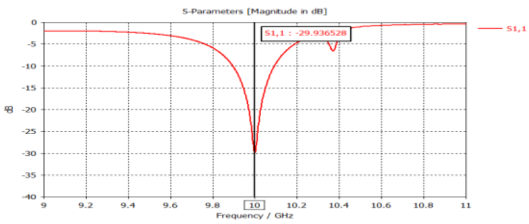


Figure7: S11-parameter Array Yagi Micro-Strip Antenna

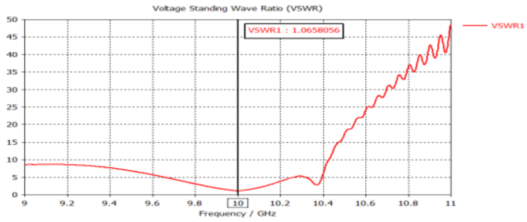


Figure8: VSWR Array Yagi Micro-strip Antenna

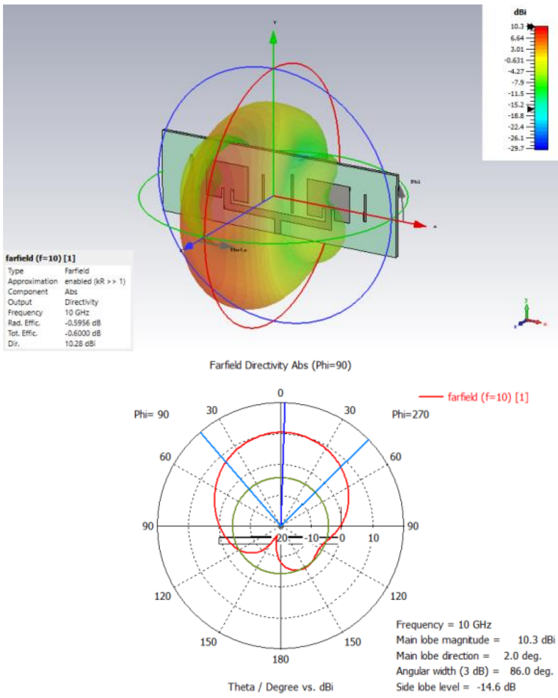


Figure9: Directivity Array Yagi Micro-strip Antenna

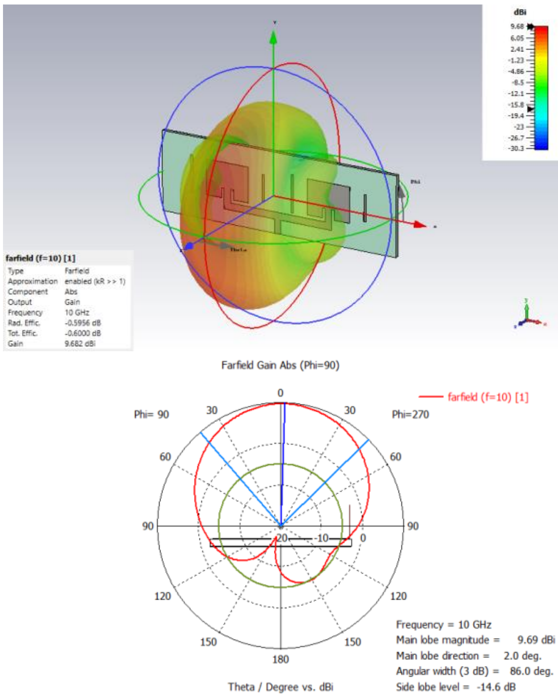


Figure10: Gain Array Yagi Micro-strip Antenna

DISSCUTION OF SIMULATION COMPARISON

CST Microwave Studio 2019 uses the operating frequency, substrate details, impedances, and electrical lengths as input to calculate the needed length and width of the feed network. The substrate permittivity (r) is 4.3 (FR4), the antenna height (h) is 0.8mm, and the antenna resonance frequency is 10GHz. Estimated the array antenna to be the best of the two plans Yagi micro-strip antenna (single & Array) based on the findings of the two plans Yagi micro-strip antenna (single & Array). The relevant characteristics are compared in Table (3), The proposed micro-strip Yagi antenna's simulated result clearly shows that the antenna directivity and gain of 10.28dB, 9.682 dB are significantly better than one branch. The planned antenna with two branches increases the directivity and gain by 4.264dB and 4.374dB, respectively, from 6.016dB and 5.308 dB for one branch. High gain antennas are recommended because they provide a longer range and higher signal quality than low gain antennas.

Table 3. comparison Results

Parameters	Single Antenna plan	Array Antenna Plan
Dimensions (Ls*Ws)	11.785*20	16*50
Returnloss	-35dB	-29.936dB
VSWR	1.03615	1.0658
Directivity	6.016dB	10.28dB
Gain	5.308dB	9.682dB

CONCLUSION

For coverage of the 10 GHz band in the X-band frequency range, a micro-strip Yagi antenna layout with array application has been presented. The antenna plan and optimization procedure is carried out using the simulation tool CST. A driven patch component, as well as a parasitically connected director and reflector component, make up the antenna. Each component's impact on antenna performance has been investigated in order to achieve high gain with low return loss. Return loss, VSWR, and gain were all included in the analysis. To plan the suggested antenna of two branches, the best micro-strip Yagi antenna plan for one branch was picked. Using a FR-4 substrate with the feeding structure on the same layer as the antenna, a simple and inexpensive fabrication approach can be used to realize the idea. The proposed antenna's performance is superior to that of a single branch antenna plan, according to the results. The increase in gain from one branch to two branches is 27%. In comparison to a single Yagi antenna component, a good Directivity and a high gain can be attained by planning the micro-strip Yagi antenna with two branches.

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