

# Directivity and Gain Improvement for Microstrip Array Antenna with Directors

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**Abstract**—Methodology is suggested to design a linear rectangular microstrip array antenna based on Yagi antenna theory. The antenna with different directors' lengths as parasitic elements were designed, simulated, and analyzed using HFSS. The calculus and results illustrate the effectiveness of using specific parasitic elements to improve the directivity and gain for microstrip array antenna. The results have shown that the suggested methodology has the potential to be applied for improving the antenna performance. Maximum radiation intensity ( $U_{max}$ ) of the order of  $0.47w/st$  was recorded, directivity of 6.58dB, and gain better than 6.07dB are readily achievable for the antenna that working.

**Keywords**—Directivity, director, gain improvement, microstrip antenna.

## I. INTRODUCTION

PARASITIC elements have been used for modifying the radiation pattern of the radio waves emitted by the driven element, which is an isolated conductive element [1].

A parasitic element act as a passive resonator, strengthening the antenna radiation in the desired direction, and cancelling out waves in undesired directions, it acts as convergent convex lens in the microstrip antenna [2].

The design considerations for the proposed antenna, the driven element is linear array consisting of four rectangular patches while the director length was taken to be proportional to the patch length [3].

To show the idea of this work, a single patch and director were designed with specific geometrical parameters.

The designing formulas and related antenna characteristic parameters as directivity, and gain were discussed in [4], [5]. Fig. 1 represents the Geometry of Yagi antenna and the proposed one.

## II. THE SUGGESTED METHODOLOGY

The block diagram that represents the procedures is illustrated in Fig. 2. It consists of two parts namely the antenna design and analysis where;  $L_D$  shorter than patch length ( $L_P$ );  $L_D$  equal to patch length  $L_D = L_P = 28.535\text{mm}$ ;  $L_D$  longer than patch length  $L_D > L_P$ .

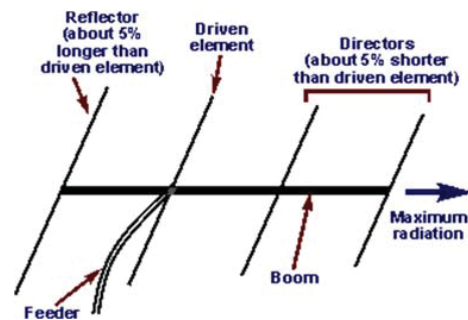
Description of the analyzed antenna parameters that are used in the comparison between these parameters in various

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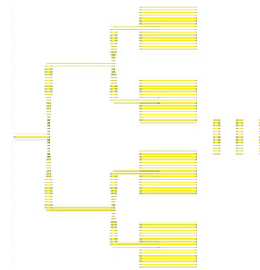
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cases with the aim to clarify the director effect on the antenna performance.



(a)



(b)

Fig. 1 (a) Geometry of Yagi antenna, (b) The proposed antenna

## III. THE ANTENNA DESIGNATION

The specifications of a single patch and director dimensions are as follows:

### A. The Antenna Shape

Fig. 3 (a) represents the array antenna without director, Figs. 3 (b), (c), and (d) represent the array antenna with one, two and three directors respectively.

### B. Single Patch Designation

The rectangular patch is analyzed using both the transmission-line and cavity models [6], hence it was proposed to design the proposed antenna working at the resonant frequency ( $f_0$ ) = 2.41 GHz, dielectric constant of Substrate ( $\epsilon_r = 4.5$ ), and height of the substrate ( $h = 1.6\text{mm}$ ).

A single patch was designed as illustrated in Fig. 4 with the following parameters; width of the patch ( $W$ ) = 37mm, length of the patch ( $L$ ) = 28.535mm, inset position ( $y_0$ ) = 9.65 mm, and inset width ( $W_0$ ) = 3 mm.

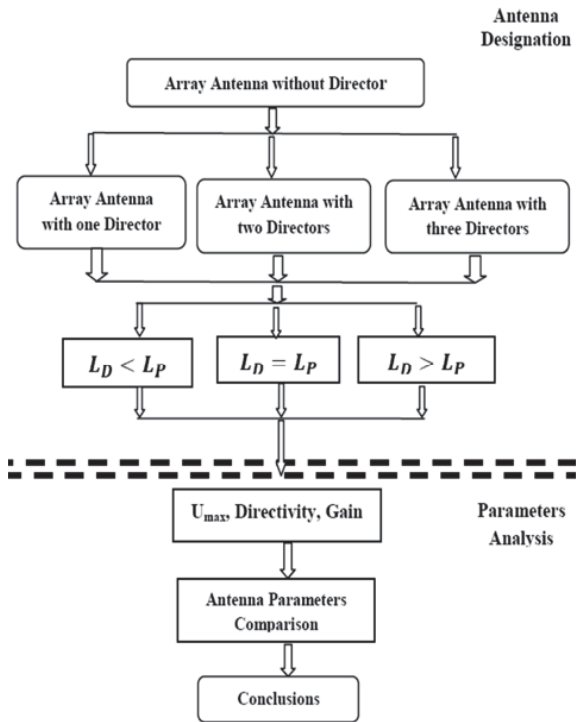


Fig. 2 Suggested methodology

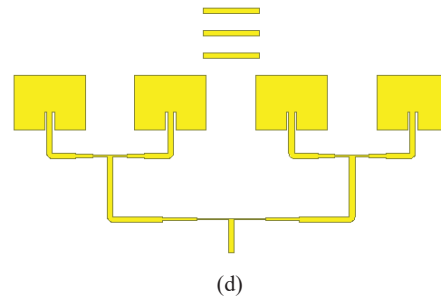
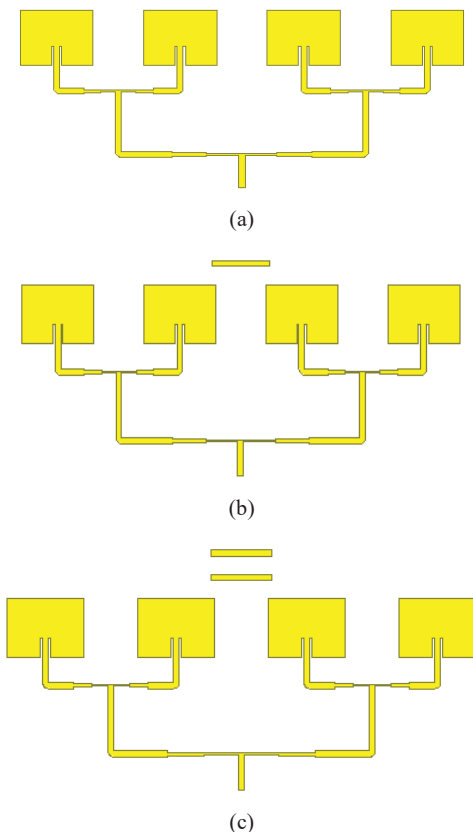


Fig. 3 Antenna Shape

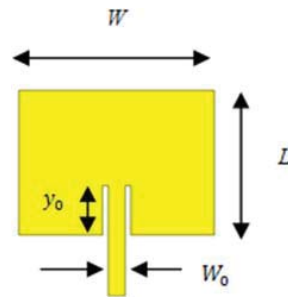


Fig. 4 Single patch

C. Director Dimension

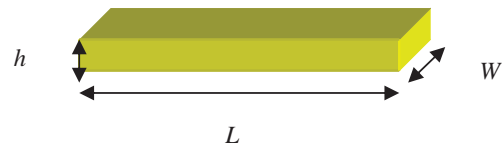


Fig. 5 Single director

Fig. 5 shows the shape of a single director; width ( $W$ ) = 37mm, various ( $L$ ) = (25, 28.535 and 29.15 mm) respectively, and height of the director ( $h$  = 1.6mm).

IV. PARAMETERS ANALYSIS

Many parameters were addressed and considered in this antenna. This section gives insight on how these parameters are affected using different numbers and lengths of directors ( $L_D$ ) compared to the length of one patch ( $L_P$ ).

Fig. 6 gives information about the maximum antenna parameters; as the values of  $U_{max}$ , peak directivity and peak gain which can be calculated by using the following equations respectively [4];

$$G = 4\pi \frac{U}{P_{in}} \tag{1}$$

$$D = \frac{U}{U_0} = \frac{4\pi U}{P_{rad}} \tag{2}$$

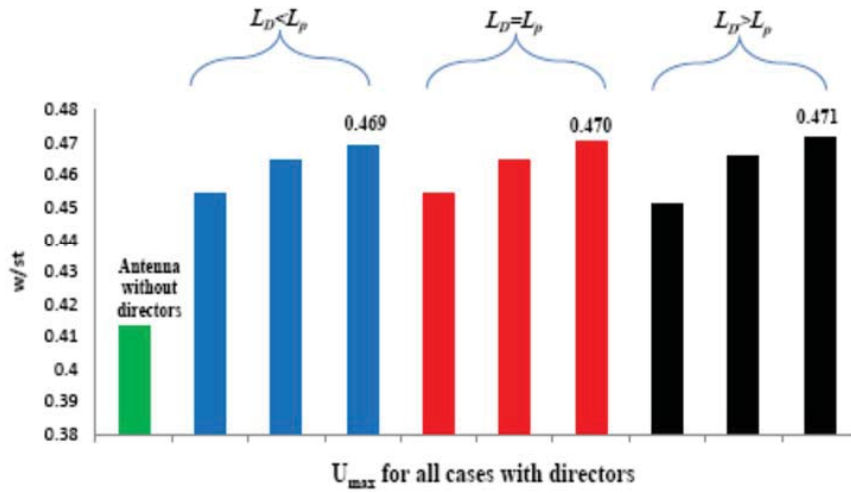
$$U = r^2 W_{rad} \tag{3}$$

where  $U$  = radiation intensity (Watt/unit solid angle);  $U_{max}$  = maximum radiation intensity;  $U_0$  = radiation intensity of isotropic source;  $P_{rad}$  = total radiated power (Watt), and  $P_{in}$  = total input (watt).

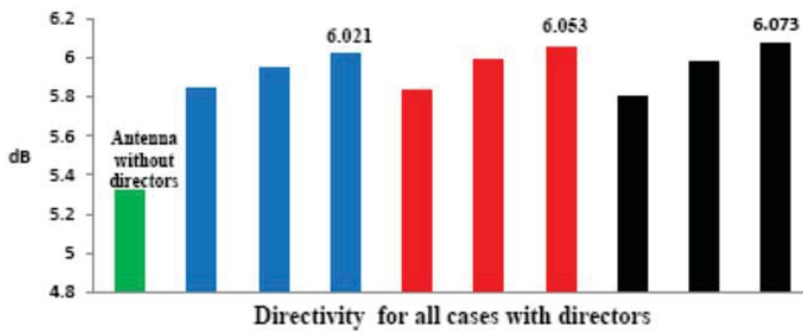
V.ANTENNA PARAMETERS COMPARISON

The calculated parameters for all cases are represented in the bar chart as shown in Figs. 6, 7; where green bars

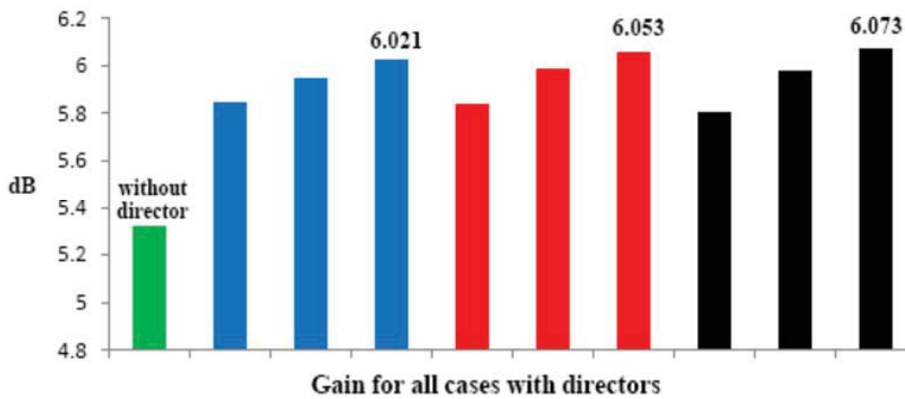
corresponding to antenna without directors; while blue, red and black bars illustrate the antenna parameters using one, two and three directors with three different lengths  $L_D < L_P$ ,  $L_D = L_P$  and  $L_D > L_P$  respectively.



(a)

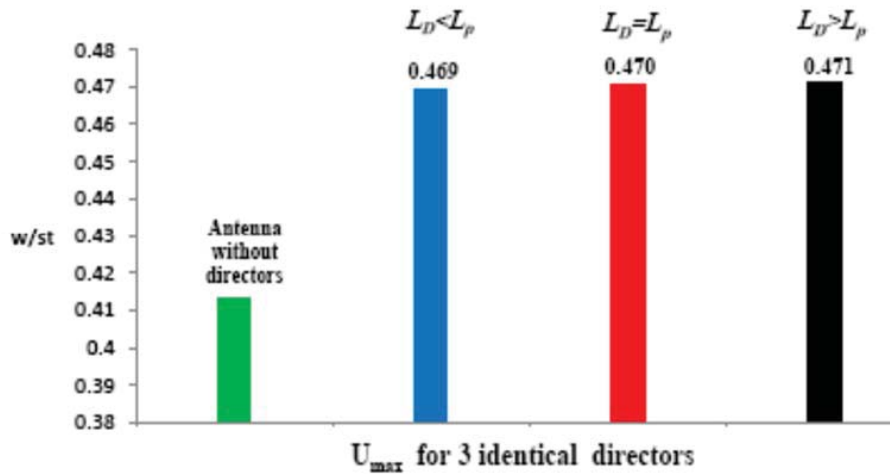


(b)

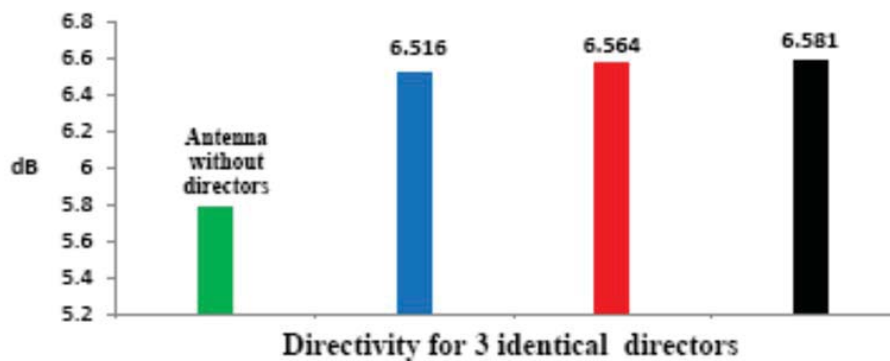


(c)

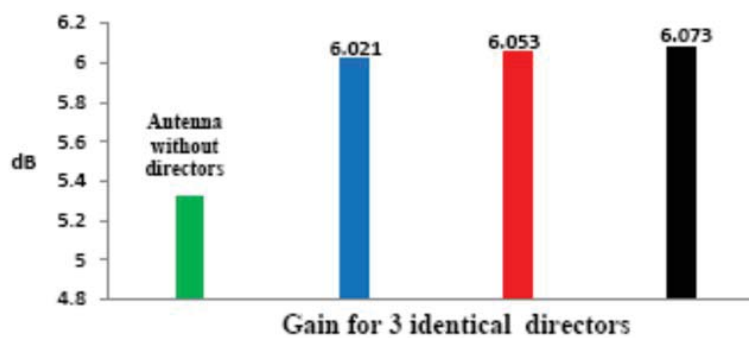
Fig. 6 Antenna parameters (a)  $U_{max}$ , (b)directivity, (c)gain



(a)



(b)



(c)

Fig. 7 Antenna parameters improvement (a)  $U_{\max}$  (b) directivity, (c) gain

From the bar charts in Fig. 6, one can notice that the improvements in antenna parameters were satisfied when using the three directors with length  $L_D > L_p = 29.15\text{mm}$  (best case) comparing with the other cases.

Fig. 7 focusing on the best case in order to have an indication for the antenna performance.

The bar charts in Fig. 7 clarify the improvement in  $U_{\max}$ , directivity and gain parameters when using best case  $L_D > L_p = 29.15\text{mm}$  compared to the case of with no directors.

$U_{\max}$  increased from 0.41 to 0.47 watts per steradian and hence the improving in the directivity and gain from 5.78 to 6.58, 5.32 to 6.07 in decibels respectively.

## VI. CONCLUSION

The approached design achieves a very substantial increase in the antenna directionality and gain compared to antenna with no directors based on Yagi-Uda antenna.

The proposed antenna array with directors was concluded as a simple and it has compact dimension.

The trend of results when using one, two and three directors indicate that, increasing the number of directors and length more than the proposed one will not effecting too much in the antenna parameters, while drastically increase the array antenna dimensions.

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