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Ankh Key Broadband Array Antenna for 5G Applications

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Abstract**—**A simple design of array antenna is presented in this paper, supporting millimeter wave applications which can be used in short range wireless communications such as 5G applications. This design enhances the use of V-band, according to IEEE standards, as the antenna works in the 70 GHz band with bandwidth more than 11 GHz and peak gain more than 13 dBi. The design is simulated using different numerical techniques achieving a very good agreement.

Keywords**—**5G Technology, array antenna, microstrip, millimeter wave.

I. Introduction

THE millimeter wave bands extend from 30-300 GHz providing up to multi-Gigabyte data transfer challenging researchers to work in this field [1], [2]. 5G technology is not available yet [3], but researchers are working on such technologies to meet their standards. FCC proposed new rules concerning the wireless broadband frequencies on October, 2015, (FCC 15-138) to be 28GHz, 37 GHz, 39 GHz, and 64-71 GHz bands [5]. Various researches were employed for the other millimeter-wave applications [4], but very few were done to support 5G technology.

In this paper, a new, simple, and low cost 2x2 array antenna design is achieved with dimensions 11.8 x 8.06 x 0.508 mm^3 using two different simulators based on different numerical techniques, Hyperlynx IE3D [6], and CST Microwave Studio [7], where IE3D is using Method of Moments (MOM) technique while CST is using Finite Difference Time Domain (FDTD). The results from both simulators showed a satisfying agreement to each other. The antenna is operating from below 60.5 GHz to 72 GHz achieving a broadside radiation pattern at the central frequency 66.25 GHz with a peak gain over 13 dBi and VSWR below 2.

II. Single Element Design and Measurements

The single element is designed to work in the V-band range supporting 5G technology. It is a simple, low cost, and easily fabricated design with dimensions 7.5 x 7.5 x 0.508 mm^3 as shown in Fig. 1. The antenna is operating in the range from below 60.5 GHz to 72 GHz with a peak gain of 8.3 dBi. The design is a typical pharaonic Ankh Key shape of dimensions 4 mm x 3.9875 mm and fed with 50 Ω microstrip line of length l_1 = 1.2625 mm and widths of w_1 = 0.7 mm, w_2 = 0.4 mm, and w_3 = 0.32 mm.

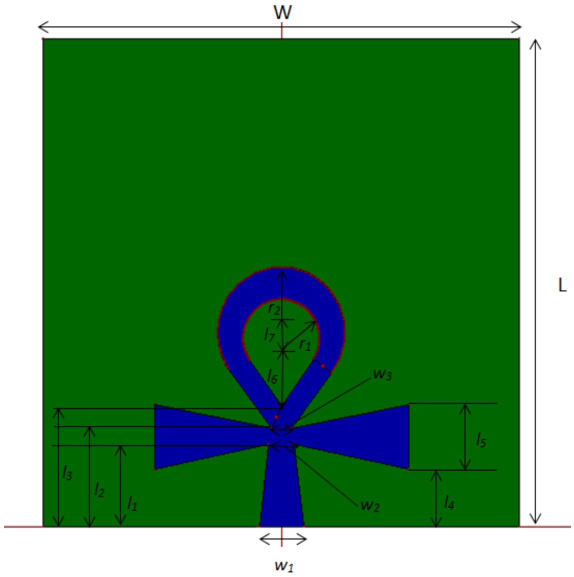

Fig. 1 Geometry of the proposed antenna

The patch is designed at a height h = 0.508 mm from the rectangular full ground plane of dimensions L = 7.5 mm and W = 7.5 mm. This height is a Rogers Duroid RT 5880 dielectric substrate having relative permittivity ε_r = 2.2 and loss tangent tanδ = 0.0009 which is considered in the calculations. Table I shows the parameters of the designed patch.

TABLE I
Parameters of the Proposed Antenna

Parameter	l_2	l_3	l_4	l_5	l_6	l_7	r_1	r_2
Dimension (mm)	1.5125	1.8675	0.8875	1	1.025	0.095	0.6	1

However, the measured results showed slight difference due to lack of facilities for measuring over 67 GHz, and using a connector with maximum frequency of 40 GHz, it showed a good agreement with the simulated results. Figs. 2 and 3 show the return loss of the two simulators compared with the measured result and the simulated peak gain, respectively.

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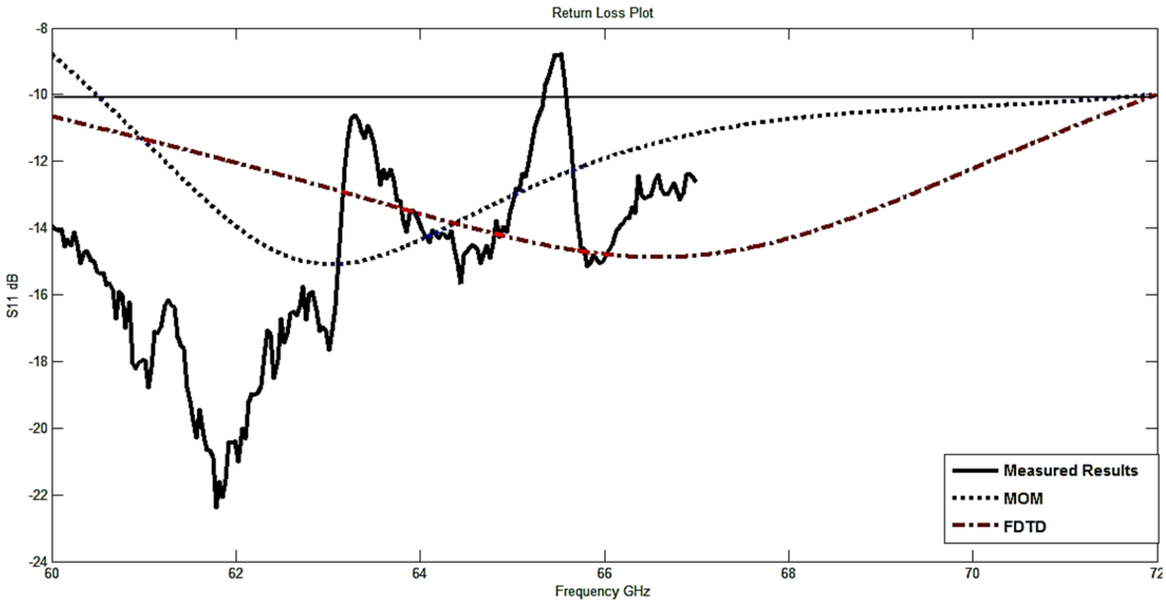


Fig. 2 Simulated and measured return loss, S_{11}, for single element

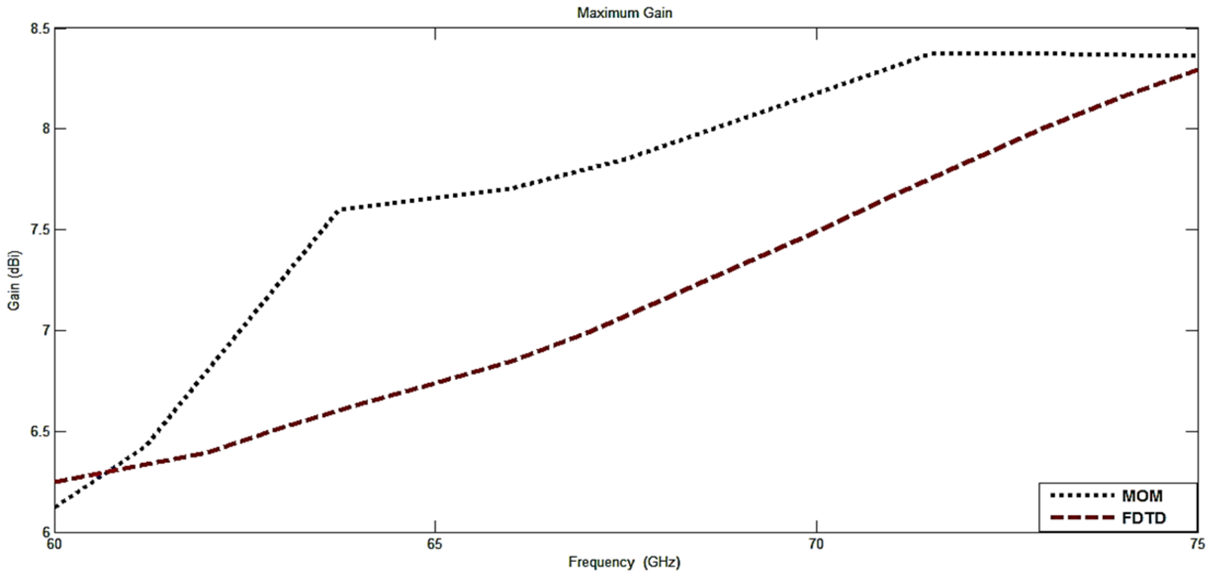
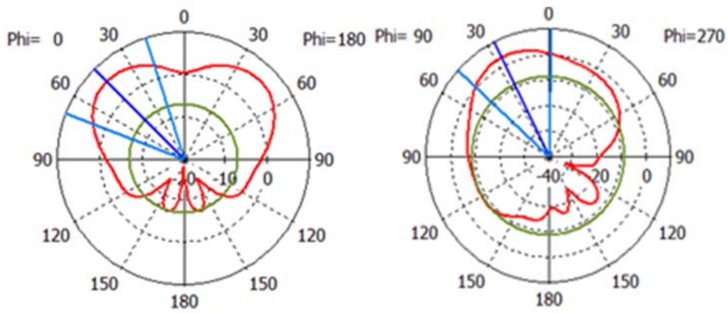
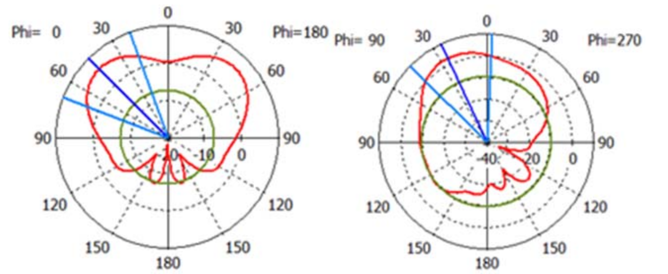


Fig. 3 Simulated peak gain for single element

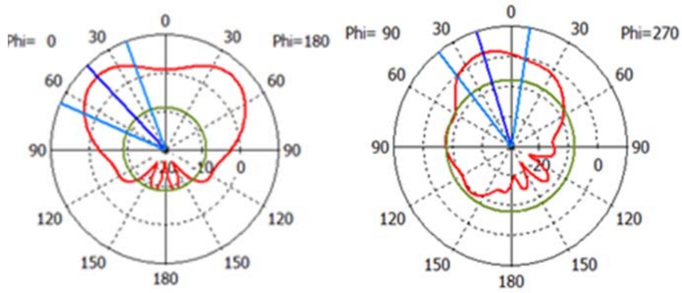


(a)

E-plane H-plane



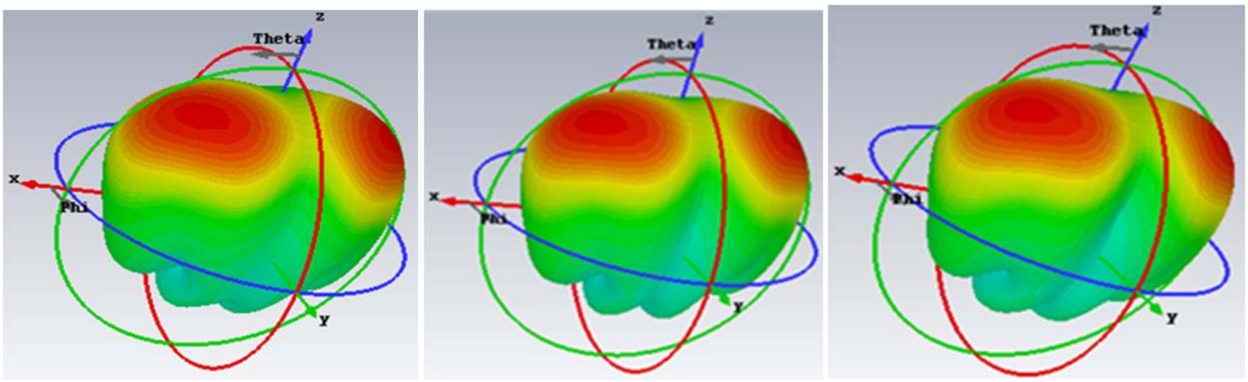
(b)



(c)

E-plane H-plane

Fig. 4 Simulated E-plane and H-plane at three different frequencies; (a) 63 GHz, (b) 67 GHz, (c) 71 GHz



(a) (b) (c)

Fig. 5 3D Radiation pattern at three different frequencies; (a) 63 GHz, (b) 67 GHz, (c) 71 GHz

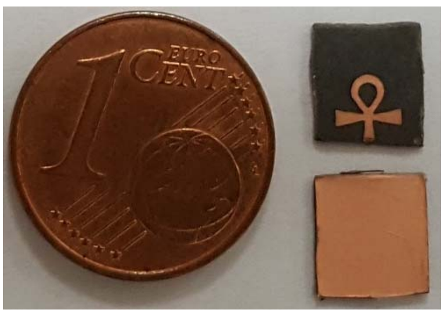


Fig. 6 Fabricated single element antenna

III. 2X2 Array Antenna Design

Fig. 7 shows the designed 4-element array having a total dimension of 11.8 mm x 8.06 mm x 0.508 mm, easy for fabrication, meeting almost the same bandwidth of the single element which extends from 60.5 GHz to 72 GHz achieving a very good coupling coefficient (S_{12}) from both simulators along the bandwidth as shown in Fig. 7 but with higher peak gain reaching of about 13 dBi as shown in Fig. 8.

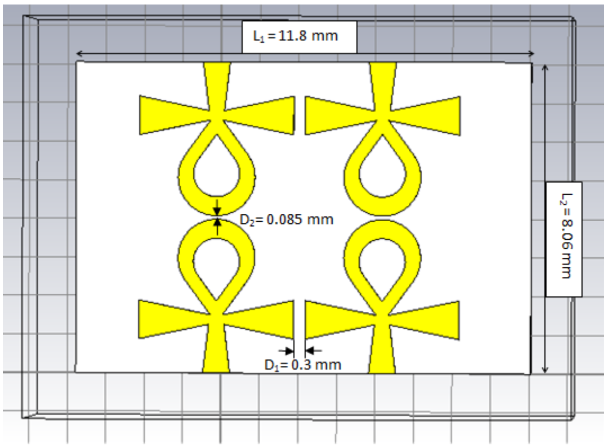


Fig. 7 4-element array antenna design

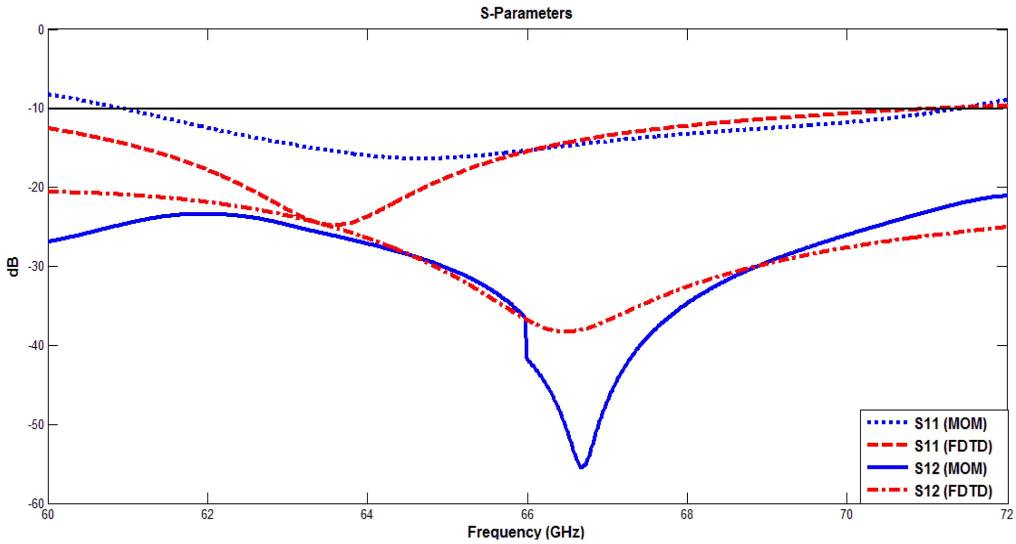


Fig. 8 Simulated S_{11} and S_{12} for the proposed array antenna using the two simulators

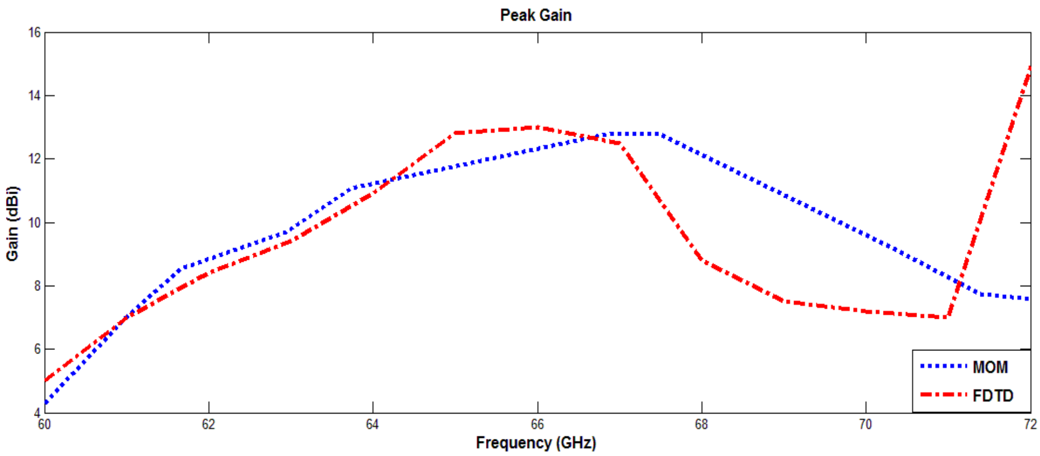


Fig. 9 Simulated peak gain for the proposed array antenna with the two simulators

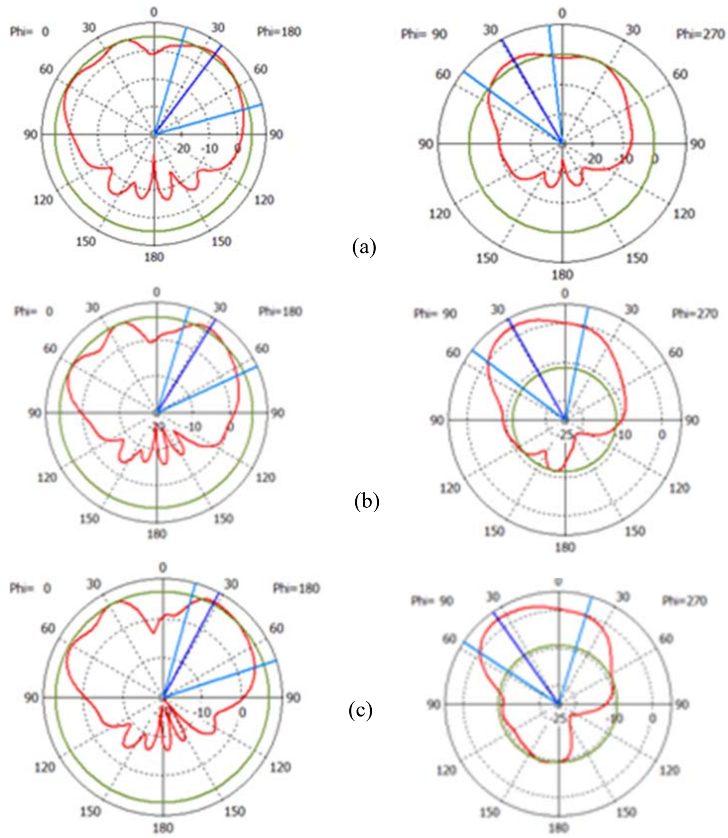
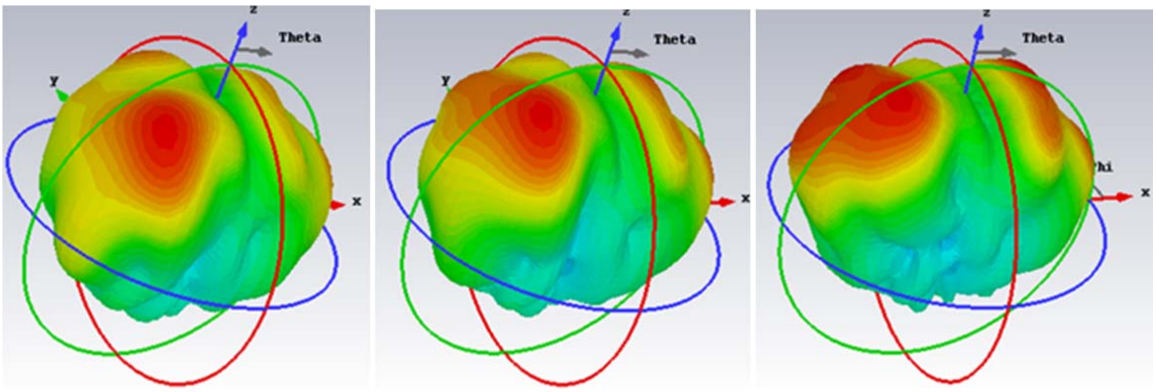


Fig. 10 Simulated E-plane and H-plane at three different frequencies (a) 63 GHz, (b) 67 GHz, (c) 71 GHz



(a) (b) (c)

Fig. 11 3D Radiation pattern at three different frequencies; (a) 63 GHz, (b) 67 GHz, (c) 71 GHz

IV. Conclusion

In this paper, a small 4-element array antenna design is proposed of dimensions 11.8 x 8.06 x 0.508 mm^3 enhancing the use of V-Band, specifically 5G technology, having a bandwidth of 11.5 GHz extending from 60.5 GHz to 72 GHz and peak gain above 13 dBi showing a very good radiation pattern in both E-plane and H-plane.

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