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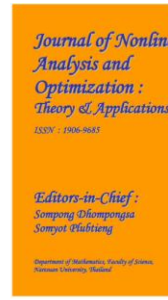

DESIGN AND ANALYSIS OF MINIATURIZED PSP ANTENNA WITH KOCH DEFECTED GROUND STRUCTURE FOR WLAN APPLICATIONS

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Abstract: The design and development of a miniaturized pentagonal slot antenna (PSA) with Meander Koch Defected Ground Structure (MK-DGS) and metamaterials-based superstrate (MM) for 5 GHz WLAN application is presented in this paper. A Meander Koch DGS was initially used to lower the resonant frequency of the PSA from 13.1GHz to 5 GHz. The proposed antenna has been miniaturized by 61.83 percent, bringing it closer to an electrically small antenna. The performance characteristics of a PSA using MK- DGS and MM superstrate, which improves efficiency, directivity, and peak gain, are also discussed

Keywords
Enhancement of gain, miniaturized, pentagonal slot antenna (PSA), Meander-Koch Defected Ground Structure (MK-DGS)..

I. INTRODUCTION

Miniaturized antennas are a growing part of research into existing wireless communication systems (WCS). As a result, it has more clout when it comes to setting a size limit for the basic blocks in the current WCS. The physical size of a basic antenna in the C-band for satellite communication applications is 41.32 mm, which can be reduced without adversely affecting its performance characteristics. As a result of this, there has been need to reduce the sizeof the element that operates at low frequencies and holds more area. Spherical mode radiating fields were mentioned by Chu et al. [1].The concept of 'electrically small antennas' is similar to that of reducing the size of antennas with Ka $\leq$ 1.0. In this case, 'K' corresponds to the wave propagation vector ($K = 2\pi/\lambda$) and 'a' represents the radius of a sphere which encircles the antenna [2].Clearly, the radiation characteristic leads to a reduction of peak gain, quality factor (Q), and impedance-bandwidth for a construction of compact antennas [3]. Miniaturized antennas with helical μ-negative (MNG) resonators were investigated by Jahani et al [4]. The size of the antenna was reduced by using the inductive slit method [5], however, the antenna area can be expanded further by using slits as well as the slot width. Ghafari et al. [6] proposed a technique for reducing the size of an antenna by using an array of T-top loaded dipoles. A multi-band antenna constructed using miniaturized split ring resonators were investigated by Dong et al.

[7].Ghosh et al. [8] looked into using the loading wire method to reduce the size of a slot antenna. Various antenna reductions in size methods [9-11] are listed based on meandering and CSRR. Fractal EBG, SRR structure, and slit loading techniques were used to investigate miniaturized antennas [12-15]. Mishra et al. [16] investigated an electric LC resonator-based metamaterial miniaturized antenna with a high gain. DGS was used to decrease the size of the patch and its array components [17-23]. Antennas designed with superstrate configurations have improved gain and directivity [24-25]. Metasurface-based miniaturization of loop antennas for wireless applications was suggested by Varamini et al. [26].The miniaturized slotted antenna for multiband applications was discussed [27-28]. To improve the gain of the metamaterial-based superstructures [29-30]. Table 1 shows the relationship between the proposed miniaturized antenna and certain DGS-basedworks.

The majority of the antennas discussed in previous work are quite large at lower frequency bands, and their peak directivity and gain are reduced at operating frequency. So, in this paper, Miniaturized PSA with MK-DGS for 5 GHz WLAN applications. The concept behind a miniaturized antenna is to switch the operating frequency from

13.1 GHz to 5GHz without changing the size of the lateral antenna. The proposed antenna achieved a miniaturization of 61.83 percent, allowing it to approach electrically small antenna status.

II. PENTAGONAL ANTENNA WITH MEANDER-KOCH DGS

The miniaturized 50 fed pentagonal slot antenna with r1 = 3.1 mm and r2=0.6mm is presented in this section using MK-DGS. The figure 1shows the prototype design and configuration for a pentagonal slot antenna, which was designed and developed on FR4 epoxy substrate with h1=1.6mm thickness and εr1=4.4 dielectric constant. The dimensions of its ground plane are Lg X Wg

= 15 X 15 mm^2.It operates in Ku-band at 13.1GHz using a 50 Ω feed with dimensions of Wf50Ω = 2.3 mm, Lf50Ω = 4.7 mm, and a lambda/4 transition feeder with dimensions of Wfλ/4 = 0.38 mm, Lfλ/4 = 3.2 mm. The mathematical equations for the 50 feeder are shown below (1) and (2) respectively.

$$L_f = \frac{L_{\lambda/4}}{\pi}\cos^{-1}\sqrt{\frac{50}{z0}} \qquad (1)$$

$$Z_0 = \frac{377}{\sqrt{\varepsilon_r\left(\frac{w}{h}+1.393+0.667\ln\left(\frac{w_f}{h}+1.444\right)\right)}} \qquad (2)$$

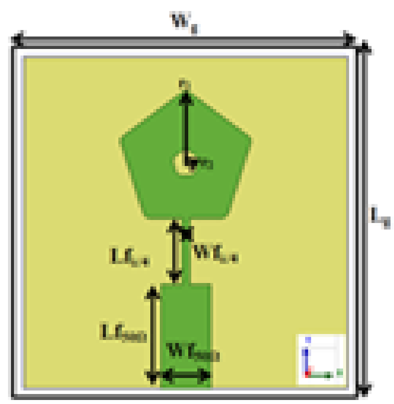
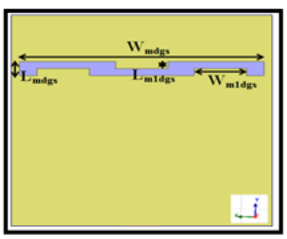


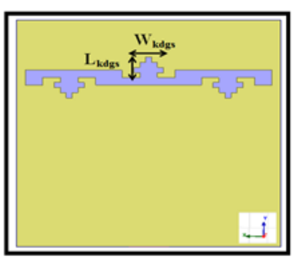
Figure 1. pentagonal slot antenna configuration

A pentagonal slot patch, a 0.3mm fillet radius is used to smooth the edge of the vertices of a pentagonal slot antenna with r1= 3.1 and r2 = 0.6 mm. To simulate and design the antenna structure, a copper conductivity of 5.8 X 10^7 Siemens/m is applied to the ground plane using the High Frequency Structure Simulator (HFSS), which can solve finite element electromagnetics, and then implemented in hardware.

Figure. 2 shows a simulated and fabricated model of a pentagonal slot antenna using a meander DGS and Koch technique where slots are loaded at the periphery of the meander with dimensions Lmdgs X Wmdgs = 14.1 X 1 mm^2 ,Lm1dgs X Wm1dgs = 0.5 X 3 mm^2,and Lkdgs X Wkdgs =1 X 1mm^2 respectively. According to the DGS principle, defects imprint on the ground plane periodically or aperiodically. The DGS is characterized by disrupted current distribution on the ground plane, which changes the values of line inductance and capacitance, thereby varying current flow and input impedances [17]. As a result, the antenna has been 61.83 percent miniaturized, bringing it closer to an electrically small antenna capable of switching from 13.1 GHz to 5GHz.



(a)



(b)

Figure 2.Steps involved in designing a proposed antenna using Meander Koch DGS: (a) Meander, (b) Koch structure,

The miniaturized pentagonal slot antenna with MK-DGS proposed here is intended to approach the Chu-limit [1] in equation 3. An antenna is surrounded by a sphere, which is represented by the letter 'a.'

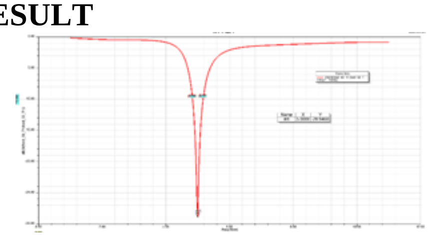
$$Q_{chu} = \frac{1}{ka} + \frac{1}{(ka)^3} \quad (3)$$

In Chu et al [1], a numerical relationship was proposed between the distribution of the source and its corresponding antenna configuration inside the sphere. A sphere with a radius of 7.5 mm is used forcalculation of the Chu-limit [31] for a miniaturized PSA loaded with MK-DGS. A pentagonal slot antenna operating at 13.1GHz has a Ka value of 2.14, while a PSA loaded with MK-DGS operating at 5 GHz has a Ka value of 0.78, achieving the Chu-limit. As a result, the proposed antenna with MK-DGS is considered an electrically small antenna. Koch curve concept is used to design the proposed geometry at the periphery of the meander with dimensions of1 X 1 mm^2. A Koch curve is divided into segments of n segments, where Wm1dgs = L Euclidian segments. A method for dividing a line segment is shown in Figure 2 d-f. An identical structure is used in all iterations to replace the middle segment. Each iteration increased the length of each line to 5/3rd of the original. As shown in Equation (4), the new length is Ln (4)

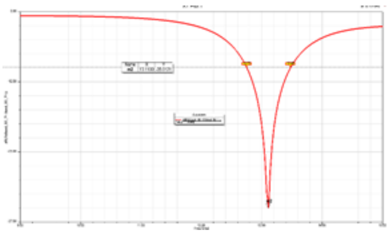
$$L_n = L\,(5/3)^n \quad (4)$$

The original line length is L, and the new line length after (n) iterations is Ln. The proposed antenna has a number of iterations of n=2.

3. RESULT



(a)



(b)

Figure 3. The simulated characteristics of return loss (S11) of (a) PSA without MK-DGS, and (b) PSA with MK-DGS.

4. CONCLUSION

The design of a 5GHz WLAN basic pentagonal slot antenna (PSA) with Meander Koch Defected Ground Structure (MK-DGS) is presented. An antenna loaded with MK-DGS has a resonant frequency reduced from 13.1 GHz to 5 GHz because of a 61.83 % miniaturization.