Fundamental characteristics of a planar folded dipole antenna with a feed line on the dielectric substrate

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1. Introduction

Recently, the many services for the cellular phone are spread. Therefore, the broadband antenna for handsets is required. In our previous paper [1], the planar folded dipole antenna (PFDA) with a feed line, which consists of two parallel lines has been introduced and its characteristics have been analyzed. As a result, it was found that PFDA with a feed line had a broadband characteristic and the feed line of a PFDA worked as an impedance transformer.

The purpose of this study is to analyze the broadband characteristics of PFDA with a feed line on the dielectric substrate. We can expect that the resonant frequency of the antenna can be lowered by using the dielectric as the substrates, which leads to the miniaturization of the antenna. First, the parametric study on the feed line with respect to the length and spacing between two parallel lines is performed by using the electromagnetic simulator (CST Microwave Studio). Next, a prototype is fabricated and measured in order to verify the simulated results.

2. Antenna and Substrate Structure

Figs.1 (a) and (b) show the structures of PFDA with a feed line in free space and on the dielectrics substrate, respectively. The center frequency is f_0 and then the wavelength is λ_0. Its construction parameters are also shown in Figs.1 (a) and (b). The antenna length is l_a, widths of upper and lower antenna elements are w_1 and w_2, respectively. The spacing between the upper and lower antenna elements is s_a. A feed line consists of two parallel lines with the length l_f, the width w_f and the spacing between two lines s_f. The length, width, and thickness of the dielectric substrate are l_s, w_s, T_s, respectively and the relative permittivity is 3.4.

3. Analytical Results

Fig.2 shows the impedance characteristics in the Smith chart and VSWR characteristics of a PFDA in free space (Fig.1 (a)) and PFDA on the dielectric substrate (Fig.1 (b)), where l_a=260mm, l_f=140mm, w_1=w_2= G_f= G_a=3mm, w_f=9mm, l_a=330mm w_s=250mm T_a=5mm.

In a free space, PFDA has two resonances around 490MHz and 600MHz, and the center frequency is 550MHz. The resonant frequency shifts down from 550MHz to 460MHz when PFDA is installed on the dielectric substrate. However, the impedance matching becomes worse and the bandwidth becomes narrower by using the dielectric substrate. In order to improve the impedance characteristics and bandwidth, we need to modify the length (l_f) and feeding gap (G_f) of a feed line on the dielectric substrate.

As was confirmed in the previous study, the locus of the impedance on the smith chart rotates around the characteristics impedance of the feed line when the length (l_f) is changed. Fig.3 shows the impedance characteristics, when the length of a feed line is shortened from 140mm to 110mm. As can be seen in the figure, the locus of the impedance characteristics shifts to the down position, and the improved impedance matching is obtained when l_f=115mm. However, the bandwidth of the antenna in a free space is narrower than that on the dielectric substrate.

Fig. 4 shows impedance characteristics, when the gap of feed line (G_f) is changed from 3mm to 10mm. As can be seen in Fig.3 (a), the locus of the impedance characteristics shifts to right position. Moreover, we can obtain two resonances around 420MHz and 490MHz. The relative bandwidth with VSWR less than 2 is evaluated to be 24%.

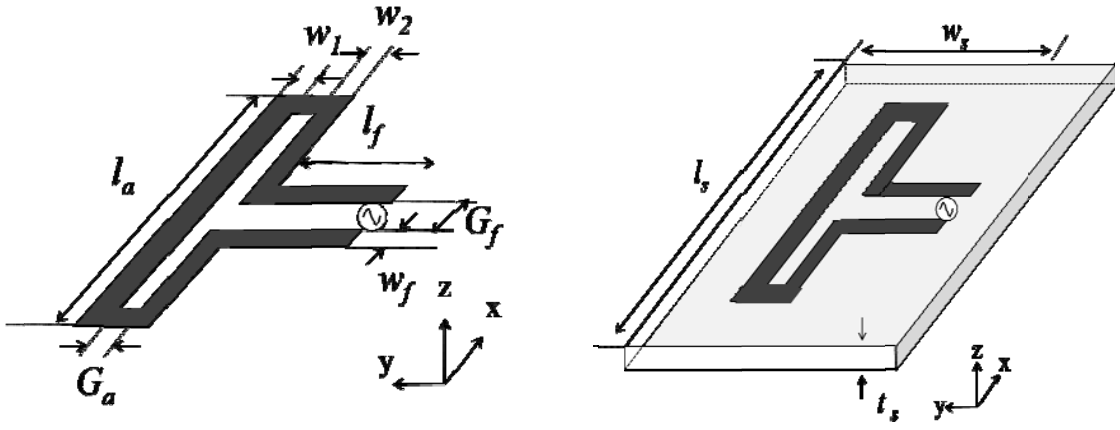
Fig.5 shows the measured and calculated results of the impedance characteristics when l_f=115mm, G_f= 9mm and feed line of PFDA is 115mm. As can been seen from the figure, the calculated and measured results are almost the same.

4. Conclusion

Fundamental characteristic of PFDA with a feed line on the dielectric substrate have been investigated for the sake of its miniaturization. As a result, we confirmed that the resonant frequency shifts down from 550MHz to 457MHz, when PFDA is placed on the dielectric substrate. However, we have to adjust antenna parameters focusing on the dimension of the feed line when the dielectric substrate is used, in order to obtain the improved impedance matching and broadband characteristics. It is thought that a feed line works as an impedance transformer, as is the same as the case when PFDA is in free space.

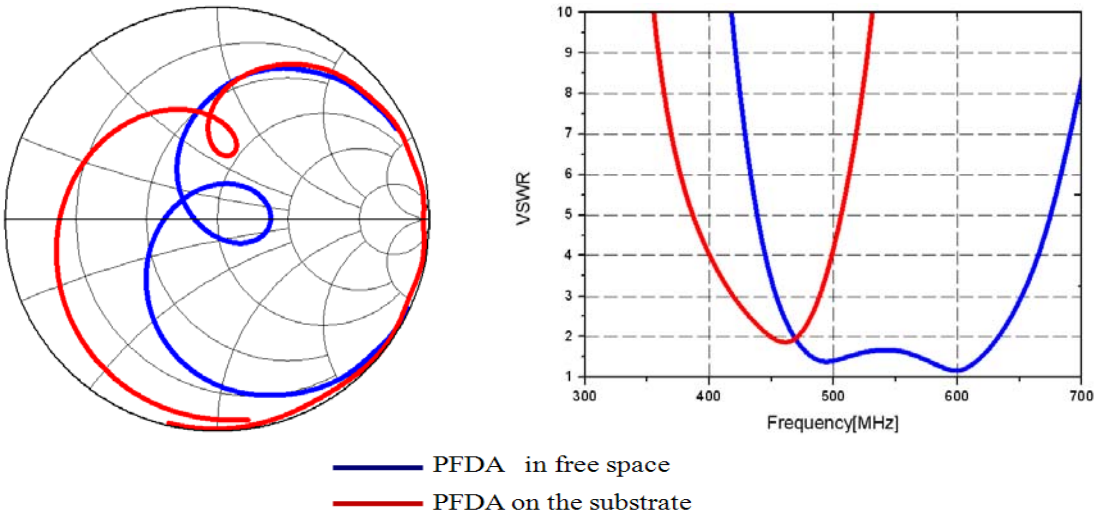
References

[1] Takashi Yamano, Jun Itoh, Yongho Kim, Masaya Hirayama, Tsutomu Miyamoto, and HisashiMorishita “Fundamental Characteristics of Planar Folded Dipole Antenna with a Feed Line” ISAP Taiwan Oct.2008,



(a) PFDA with a feed line in free space (b) PFDA with a feed line on the dielectric substrate

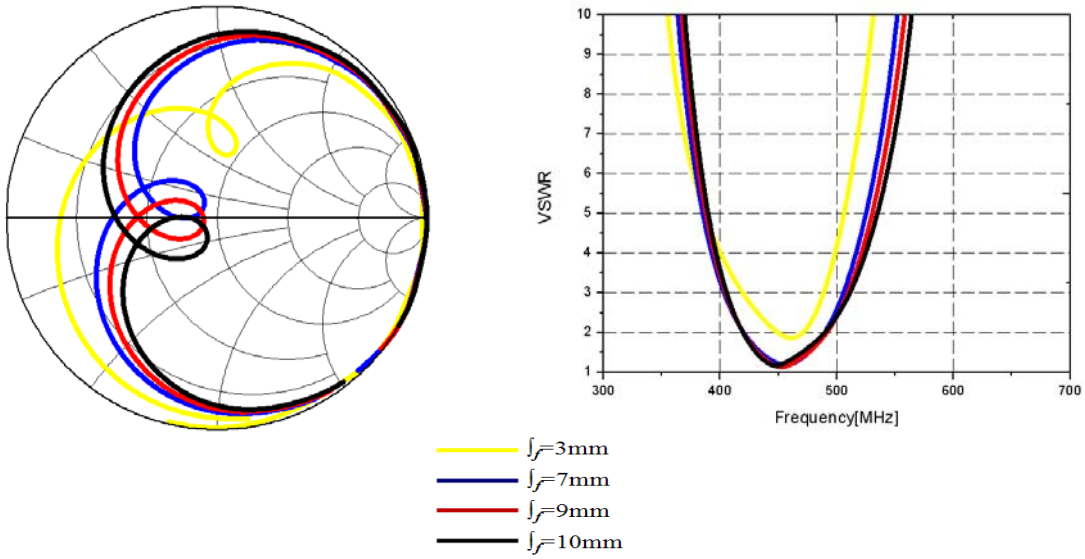
Figure 1: Antenna Structure.



Start Frequency 300MHz
Stop Frequency 700MHz

(a) On a Smith chart (b) VSWR

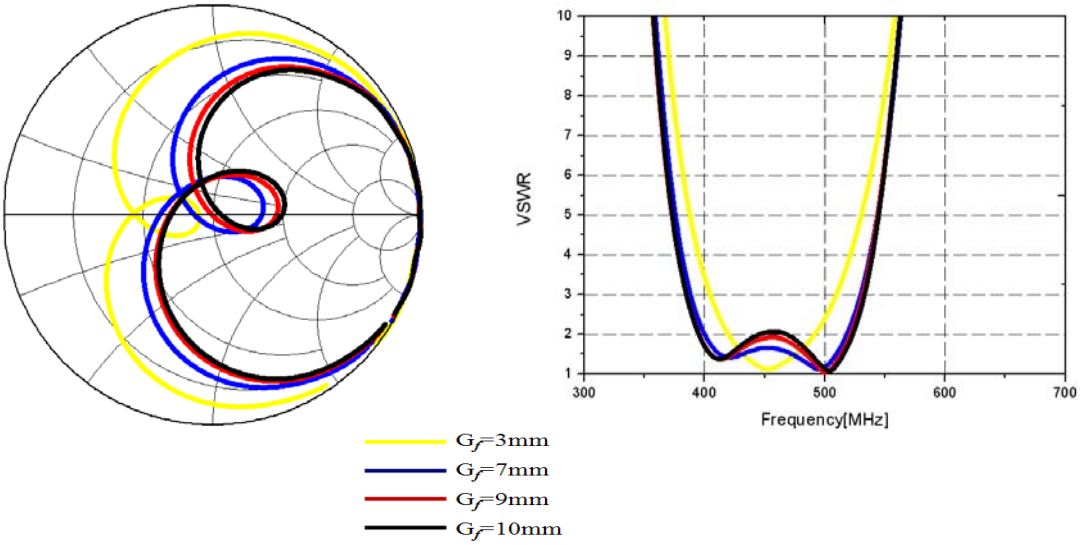
Figure 2 : Input impedance characteristics.



Start Frequency 300MHz
Stop Frequency 700MHz

(a) Smith chart (b) VSWR

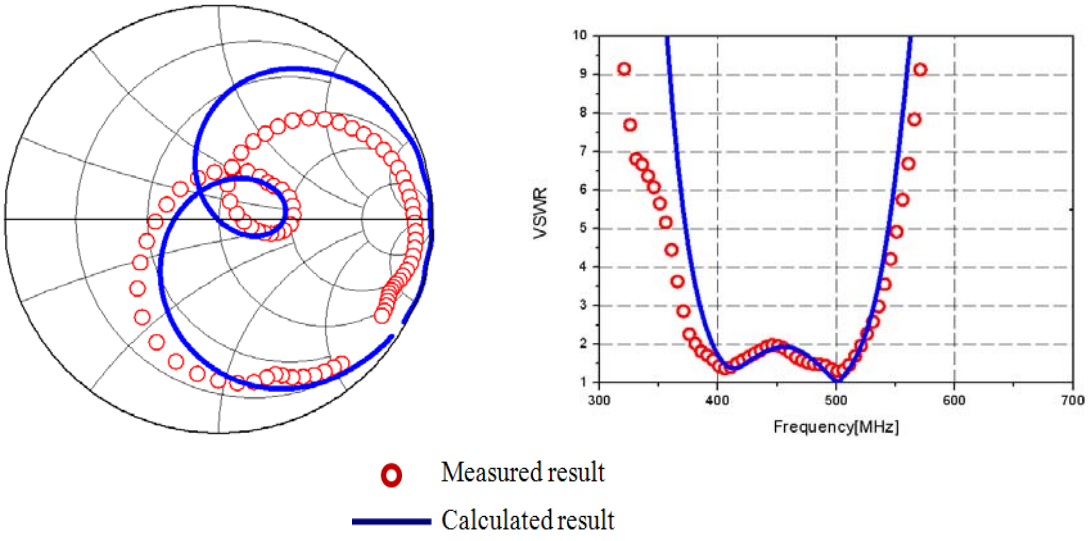
Figure 3 : Input impedance characteristics with respect to the length of the feed line.



Start Frequency 300MHz
Stop Frequency 700MHz

(a) On a Smith chart (b) VSWR

Figure 4 : Input impedance characteristics with respect to the spacing between two parallel lines.



Start Frequency 300MHz
Stop Frequency 700MHz

(a) On a Smith chart (b) VSWR

Figure 5 : Measured and calculated results of the input impedance characteristics.