Study of a Line Configuration and Coupling Method in a Partially Driven Array Antenna with Transmission Line Coupling

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1. Introduction

In the former partial drive technique, which contributes to the cost reduction of array antenna (AA), a part of the whole radiating elements are driven, and the rest are excited by spatial coupling[1][2]. This technique can realize the performance approximately equivalent to that of a fully driven AA(FDAA). But the configuration is limited in design freedom due to spatial coupling. In that case, it is necessary to optimally determine the height and the spacing of elements. Thus we have proposed a method to connect the driven and parasitic elements by using a transmission line in order to get sufficient coupling even in a printed antenna, and named it “a partially driven array antenna (PDAA) with transmission line coupling " [3][4].

In this paper, we have examined the influence of the feeding method and the transmission path configuration on the antenna characteristics.

2. Analysis Model of Basic PDAA with Transmission Line Coupling

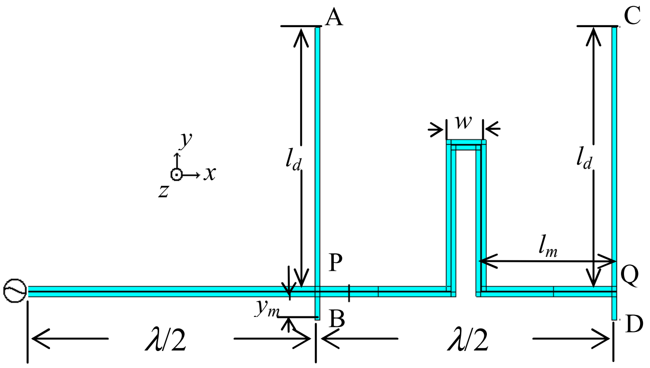


Fig.1 Basic PDAA with Transmission Line Coupling

Figure 1 shows the proposed basic configuration of a PDAA with transmission line coupling. All elements and transmission lines are composed in co-planer lines. The half wavelength dipole AB is driven, and CD is parasitic. Two pairs of co-planer transmission lines connect between AB and CD, and are located in a symmetrical arrangement between AB and CD. The total length of the transmission line between AB and CD is $l_{total} = 2(l_m + l_n) + w$. In all results, a reflective plate with infinite size is placed at a distance of $\lambda/30$ (λ: wavelength) parallel to the x-y plane.

Using the moment method, we analyzed the antenna system with a feeding voltage of 1V. In order to drive the whole element in phase, the transmission line connecting the point P and the point Q is required to have length of a wavelength. From the previous results [3], we select an odd configuration of the coodinators rather than an even one to achieve a better radiation pattern.

Figure 2 shows that S_{11} plot versus frequency as a function of the connection point y_m of the feeder line and the element. Other parameters are as follows; the lement length $l_d = \lambda/2 = 61\text{mm}$ and the total transmission line length $l_{total} = \lambda = 122\text{mm}$. The abscissa is frequency f and the ordinate is S_{11}. At width $y_m = 6\text{mm}$, S_{11} takes the minimum value.

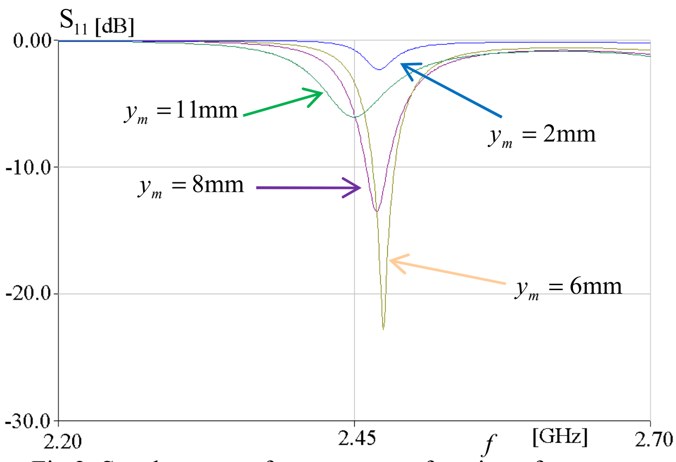


Fig.2 S_{11} plot versus frequency as a function of y_m ($l_d = \lambda/2$, $l_{total} = \lambda$).

Figure 3 shows S_{11} plot versus frequency as a function of the total transmission line length l_{total}. Other parameters are as follows $l_d = 61\text{mm}$ and $y_m = 6\text{mm}$. The abscissa is frequency f and the ordinate is S_{11}. At $l_{total} = 127\text{mm}$, S_{11} takes the minimum value.

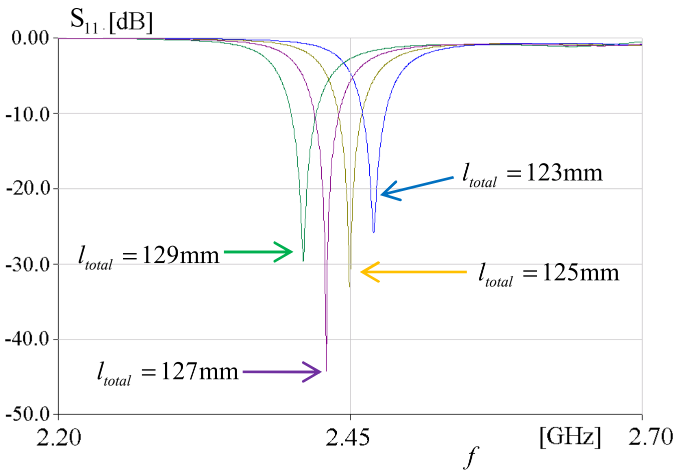


Fig.3 S_{11} plot versus frequency as a function of l_{total}

Figure 4 shows S_{11} plot versus the element length l_d. Other parameters are as follows; $l_{total} = 127\text{mm}$, and $y_m = 6\text{mm}$. The abscissa is the element length and the ordinate is S_{11}. At $l_d = 59.5\text{mm}$, S_{11} takes the minimum value.

Figure 5 shows S_{11} plot versus the length w of the part of transmission line. Other parameters are as follows $l_d = 59.5\text{mm}$, $l_{total} = 127\text{mm}$ and $y_m = 6\text{mm}$. The abscissa is the length w and the ordinate is S_{11}. At $l_d = 59.5\text{mm}$, S_{11} takes the minimum value.

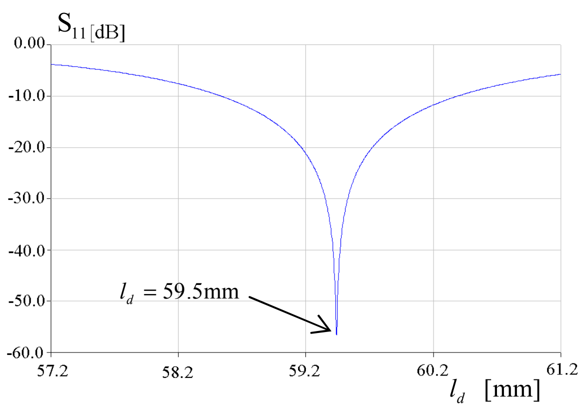


Fig.4 S_{11} plot versus the element length l_d. (l_{total} = 127mm, $y_{m\cdot}$ = 6mm).

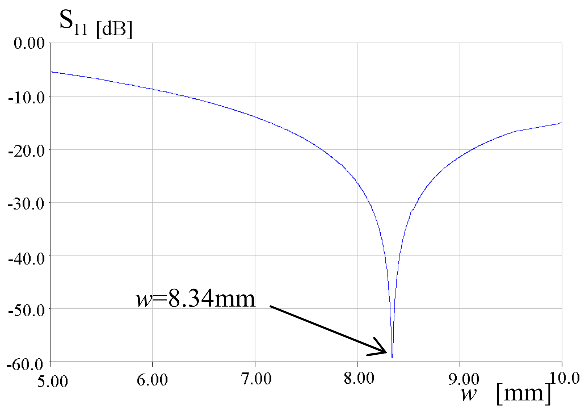
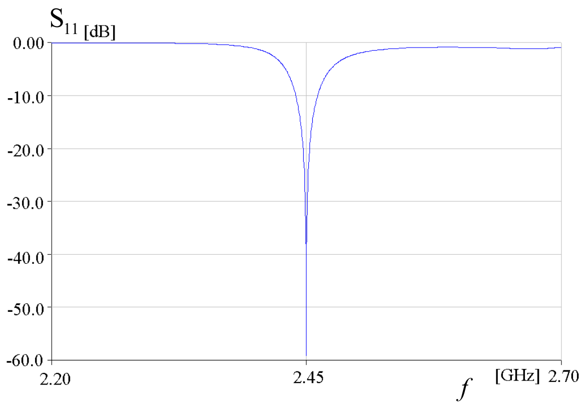
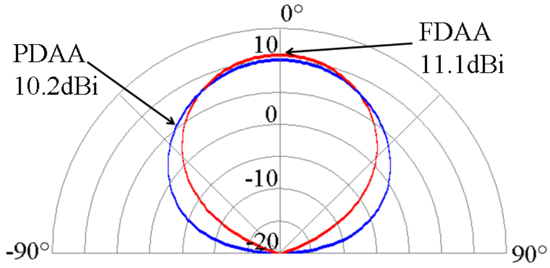


Fig.5 S_{11} plot versus w (l_d = 59.5mm, l_{total} = 127mm, $y_{m\cdot}$ = 6mm).



(a) S_{11} plot versus *f*.



(b)Radiation pattern (*f* =

Fig.6 Final results after all parameters adjusted (y_m = 6mm, l_d = 59.5mm, l_{total} = 127mm w = 8.34mm).

All parameters are adjusted, and the result is shown to Fig. 6. Very excellent S_{11} is obtained at the frequency 2.45GHz (refer Fig.6(a)). Figure 6(b) shows the radiation pattern of PDAA and FDAA. This PDAA has almost the same characteristics as FDAA, but the beam width is wider than FDAA by ± 10 degree.

4. Analysis Model of PDAA with Modified Transmission Line Coupling

We proposed another configuration that is shown in Fig.8. The main difference from the basic PDAA is the connecting part of transmission line and the antenna elements. The pair line is connected with the antenna element by the spacing of a, and another parameter definitions are the same as the basic PDAA.

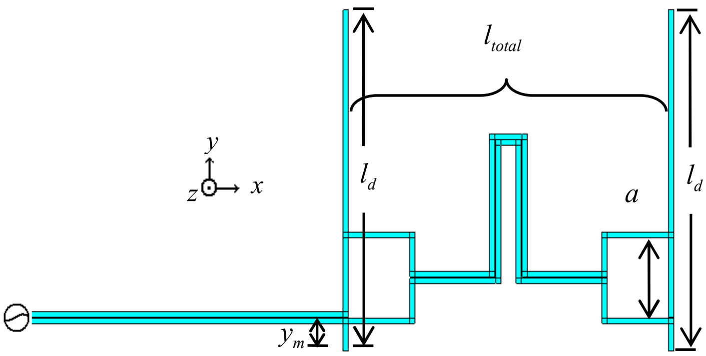


Fig.8 PDAA with Meander Modified Transmission Line

Figure 9 shows S_{11} change according to the transmission line connection width a. The abscissa is the transmission line width 'a' and the ordinate is S_{11}. Other parameters are as follows; $l_{total} = 125\text{mm}$, $l_d = 58.5\text{mm}$, $y_m = 6\text{mm}$ and $w = 8.34\text{mm}$. At $a = 15.3\text{mm}$, S_{11} takes the minimum value.

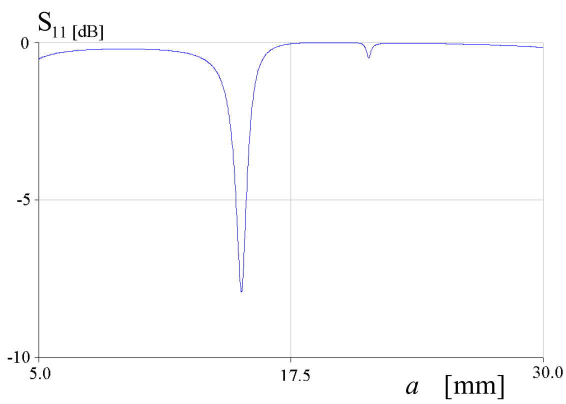


Fig.9 S_{11} plot versus the transmission line connection width a (l_{total}=125mm, y_m. = 6mm, l_d = 58.5mm w =

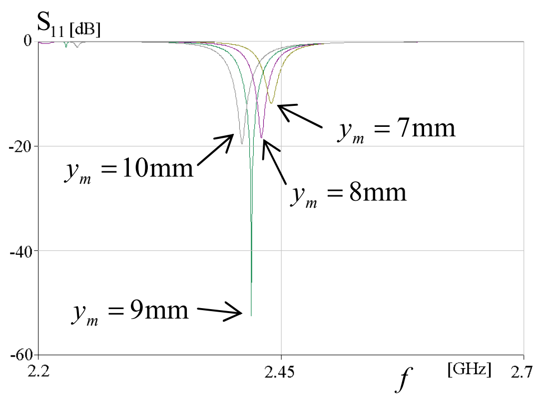


Fig.10 S_{11} plot versus *f* as a function of y_m (l_{total} = 125mm, a = 15.3mm, l_d = 58.5mm, w= 8.34mm).

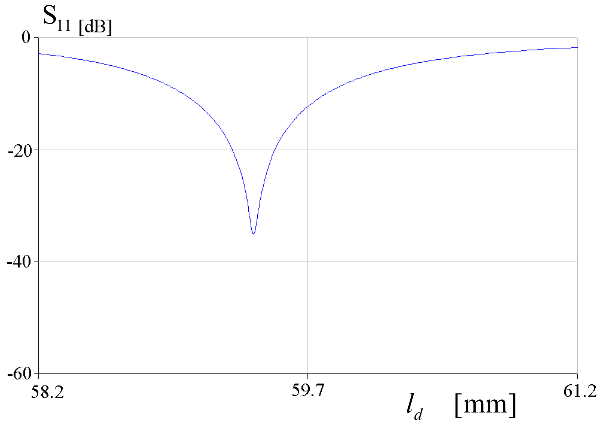


Fig.11 S_{11} plot versus the element length l_d.
(l_{total} = 125mm, a= 15.3mm, y_m. = 9mm,

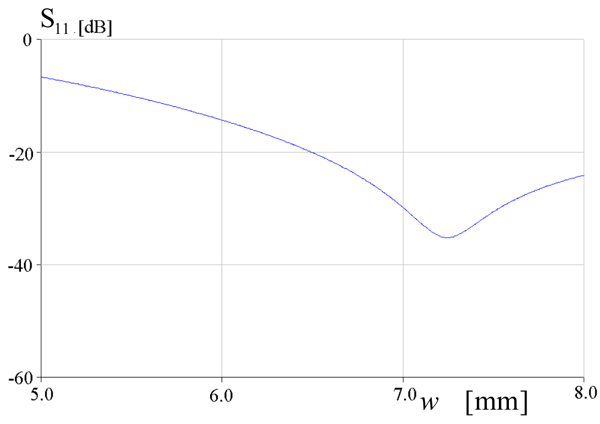


Fig.12 S_{11} plot versus w.
(l_{total} = 125mm, a= 15.3mm, y_m. = 9mm

Figure 10 shows that S_{11} plot versus frequency as a function of the connection point y_m. Other parameters are $l_{total} = 125\text{mm}$, $a = 15.3\text{mm}$, $l_d = 58.5\text{mm}$ and $w = 8.34\text{mm}$. At $y_m = 9\text{mm}$, S_{11} takes the minimum value.

Figure 11 shows that S_{11} the element length l_d. Other parameters are $l_{total} = 125\text{mm}$, $a = 15.3\text{mm}$, $y_m = 9\text{mm}$ and $w = 8.34mm$. The abscissa is the element length and the ordinate is S_{11}. It is at $l_d = 58.8\text{mm}$ that S_{11} takes the minimum value.

Figure 12 shows that S_{11} plot versus the length w of the part of transmission line. Other parameters are $l_{total} = 125\text{mm}$, $a = 15.3\text{mm}$, $y_m = 9\text{mm}$ and $l_d = 58.8\text{mm}$. The abscissa is the length w and the ordinate is S_{11}. It is at $w = 7.25\text{mm}$ that S_{11} takes the minimum value.

Being possible to say to both model, it is important to adjust the connection point y_m to decrease S_{11}.

5. Conclusion

We showed the influence on the antenna characteristics by changing the feeding method and the transmission path shape about PD-AA.

S_{11} can be decreased by optimizing the position of the feeding point and the transmission path. Especially, it is important to adjust the connection point y_m to decrease S_{11}. But we have many parameters of the antenna, and it is considerably difficult to optimize. Therefore, it is necessary to establish more convenient method for optimization.

References

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[4] Hiroyuki Hosono, Ryo Yamamoto, Kenji Saegusa, and Tadashi Takano,“Characteristics Dependence of a Partially Driven Array Antenna Using Transmission Line Coupling on the Thickness of a Dielectric Substrate,” ISAP2011, FrP1-23.