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# RADIATION CHARACTERISTICS OF NOVEL PRINTED ANTENNA COMPOSED OF DUAL ELEMENTS WITH DIFFERENT SHAPE

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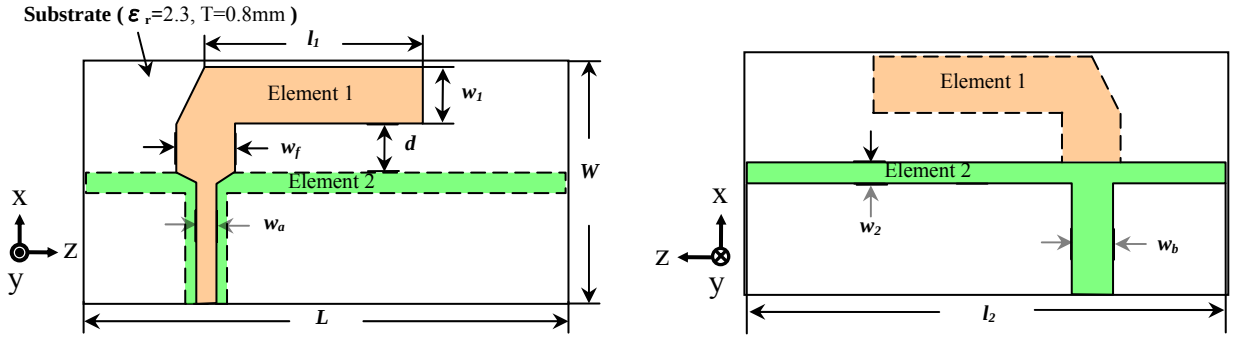
## 1. Introduction

Recently, the small, thin and lightweight antenna which works in the wide band is required for mobile communication systems or ultra wide band radio communication systems. As one of such wide-band antennas, the linear antenna composed of dual elements with different length was proposed [1], [2]. That antenna is constructed of a parallel-wire transmission line with different length terminated by the open circuit at the end, and originated from the idea that the undesired emission is occurred at the parallel-wire transmission line if the length of the wires is different [3]. However, it is difficult to produce easily since the structure of this linear antenna is complicated by combining with wires. Planar printed antennas have received much special attention for many practical applications due to their low profiles, light weights and easy fabrication. Then, the authors focused on the printed antennas and considered realizing the proposed wire antenna as a printed antenna. We measured the radiation characteristic of the antenna with two different elements, one is short and wide and the other is long and narrow, on the each side of the substrate and showed that this antenna has the relative bandwidth ratio of 45% in which VSWR is less than two [4]. In this paper, we propose the shape of each of this antenna element in order to extend the operation bandwidth furthermore, and present the measured characteristics of this novel antenna such as input impedance, VSWR and radiation pattern.

## 2. Fundamental antenna structure

Fig.1 shows the fundamental configuration of the propose antenna. It consists of two elements with different length by the element 1 with $l_1$=39mm and $w_1$=10mm on one side of the substrate (relative permittivity $\varepsilon_r$=2.3, thickness T=0.8mm, L=106mm, W=54.4mm), and the element 2 with $l_2$=104.8mm and $w_2$=4mm on the other side. The element 1 is placed parallel with the element 2 at the distance $d$. And, the element 1 is connected with the microstrip line, whose line width $w_a$=2.4mm, through the connection part. The connection part of width $w_f$ is connected with element 1 and microstrip line through the transitional part respectively. The element 2 is connected with the ground plane of the microstrip line with $w_b$=7mm.




(a) The front (element 1) side (b) The back (element 2) side

Fig.1 Structure of fundamental antenna

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## 3. Measurement of radiation characteristics

In order to search for appropriate configuration parameters of the antenna, we measure input impedance, VSWR and radiation pattern of the antenna. VSWR and input impedance are obtained fromthe measurement for the $S_{11}$ parameter by the network analyzer. Radiation pattern is measured with the network analyzer in an anechoic chamber (size:10m(L)×6m(H)×5m(W)). In order to evaluate width of operational frequency of the antenna, we define the bandwidth ratio $k$ given by

$$k=(f_u-f_l)/f_0 \ldots(1)$$

where $f_u$ is the upper limit frequency and $f_l$ is the lower limit frequency that VSWR is two or less, and $f_0$ is the center frequency.

### 3.1 Antenna added triangular plate S

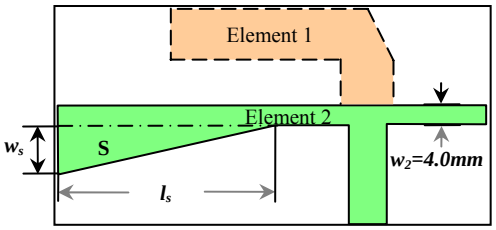
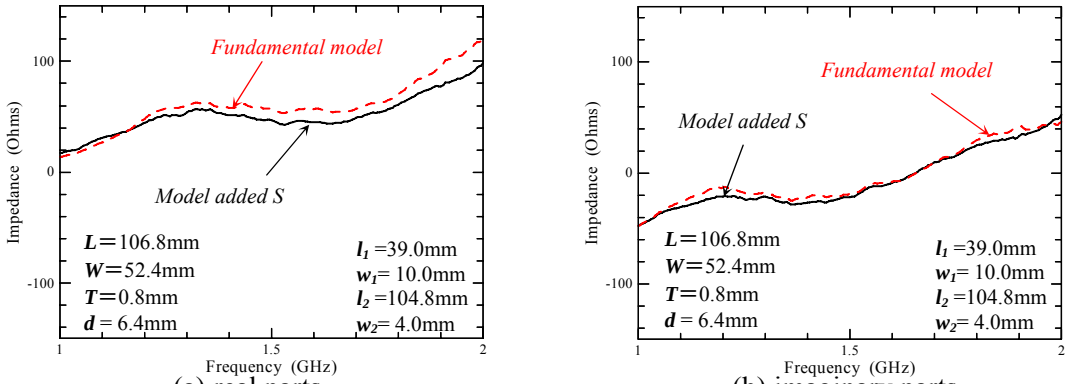



Fig.2 Structure of added patch S

Fig.2 shows the configuration of the antenna added triangular plate S. It is constructed by adding the triangular plate S to the end part of the element 2 in order to extend the operational frequency bandwidth.

To show the effect of S, we measure the impedance of the antenna. The parameters of S are $l_s$=52.0mm and $w_s$=12.0mm. The results of real parts and imaginary parts are respectively shown in Fig.3 (a) and (b) as a function of frequency. The fundamental model's case in Fig.1 is shown for comparison. As shown in Fig.3, it is




(a) real parts (b) imaginary parts

Fig.3 Comparison of input impedance to added patch S and original model

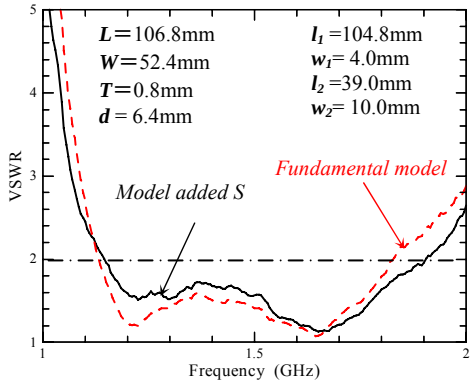


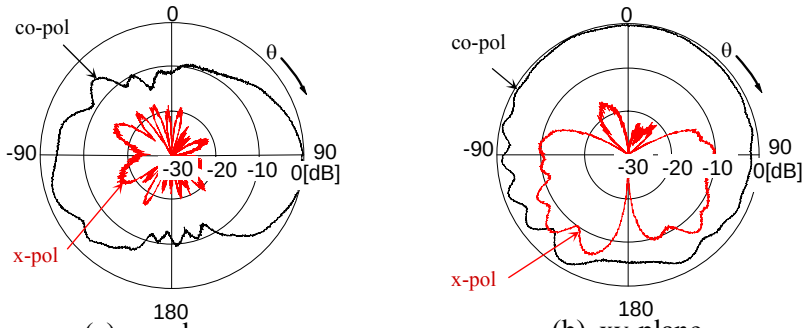

Fig.4 Comparison of VSWR to added patch S and original model

shown that the real parts of the impedance are flat and their values are about 50Ω over the range from 1.2GHz to 1.8GHz. Moreover, the values in the case of the model added S are slightly smaller than the cases of the fundamental antenna. The values of the both case are almost same with regard to imaginary parts over the range of frequencies observed.

VSWR of the antenna is measured and shown in Fig.4. As seen in Fig.4, VSWR is less than two over the wide range of frequencies. For the bandwidth in which VSWR is less than two, the case of the model added S, had $k$≒50%, that is wider than the case of the fundamental model. Therefore, adding the triangular plate to the end of the element 2 is efficient to extend the operational bandwidth of the antenna.

The radiation pattern of the antenna added S with same parameters at the Fig.3 is measured at 1.52GHz which is center frequency of this antenna. The measured results observed on xz-plane and xy-plane is shown in Fig.5 (a) and (b), respectively. Fig.5 shows that for xz-plane, the radiation pattern of the antenna is similar to that of the λ/2 dipole except for no null at φ=0 and 180°, and the level of cross polarization is small. For xy-plane, the radiation pattern is about omnidirectional. The level of cross polarization is larger than the case for xz-plane especially at φ=135° and 225°. The

reason of this difference seems to be the effect of undesired emission from the microstrip line and the discontinuity connected with this line.

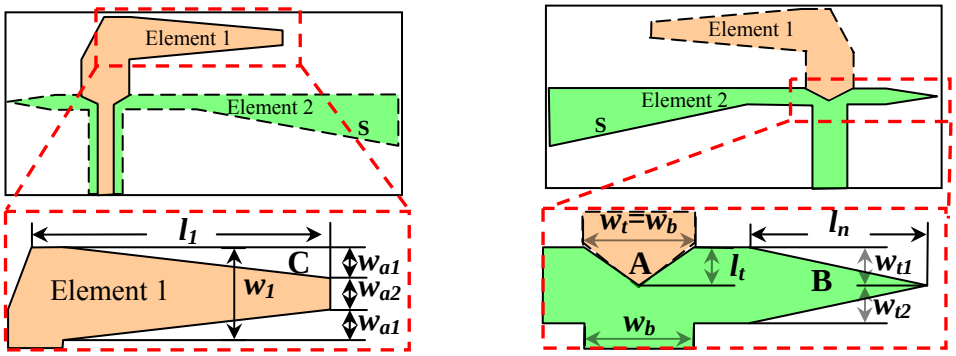



(a) xz-plane (b) xy-plane

Fig.5 Radiation pattern of model added S

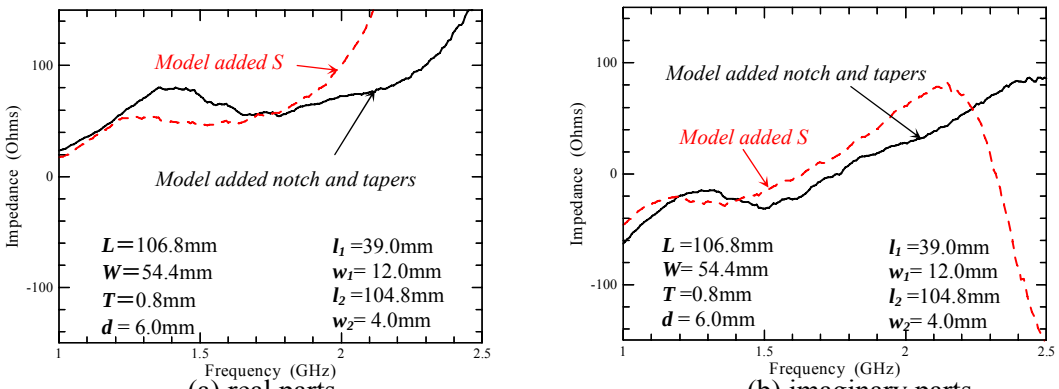
### 3.2 Antenna added notch and tapers

Fig.6 shows the configuration of the antenna added the notch and two tapers. In order to reduce the effect of the discontinuity of the junction of the microstrip line and the transition, we add a notch **A** on the ground under the junction on the element 2 [5]. Moreover, we add two tapers, one **B** on the other end of S on element 2 and the other **C** on element 1. The notch has width $w_t$=$w_b$=7mm and length $l_t$= 0.7w$_2$ as shown in Fig.6 (a). The taper **C** which is on element 1 has upper and lower width $w_{a1}$=4.0mm and and center width $w_{a2}$=4.0mm and length $l_1$=39.0mm as shown in Fig.6 (a). The other taper which is on element 2 has upper width $w_{t1}$= 2.0mm, lower width $w_{t2}$=2.0mm and length $l_n$=14.2mm as shown in Fig.6 (a).




(a) The front side (b) The back side

Fig.6 Structure of added notch and tapers




(a) real parts (b) imaginary parts

Fig.7 Comparison of input impedance between model added notch and tapers and added model S

The input impedance of the antenna added notch and tapers is measured. The results of real parts and imaginary parts are respectively shown in Fig.7 (a) and (b). For the comparison, the results of the antenna added patch S is also shown. In Fig.7 (a), it is shown that the frequency range in which impedance values are about nearly 50Ω is extended to about 2.1GHz for the case of the antenna added the notch and the tapers, but the values become slightly large at near 1.4GHz. Consequently,

the impedance values are roughly flat and 50Ω over the range from 1.5GHz to 2.1GHz. Furthermore, as shown in Fig.7 (b), the slope of the imaginary parts for the case added the notch and taper becomes gentle and small.

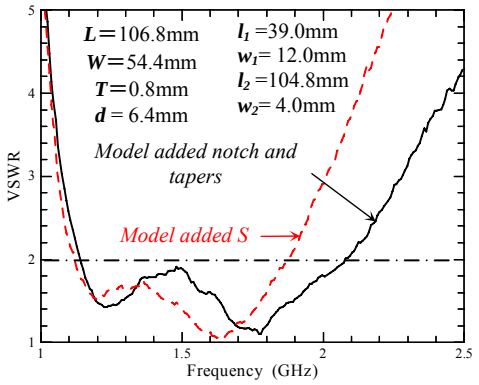
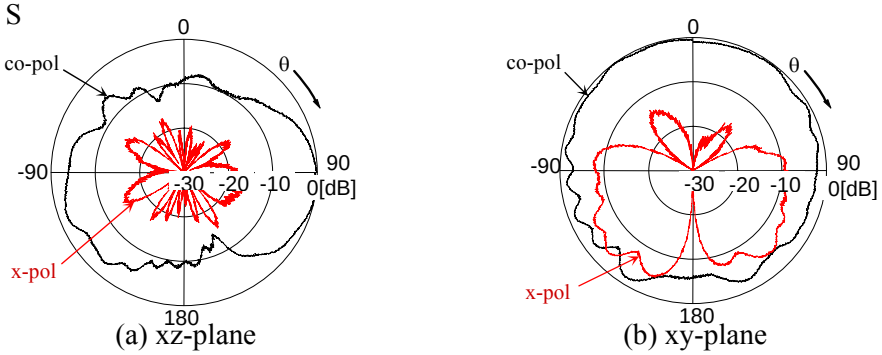



Fig.8 Comparison of VSWR between model added notch and tapers and added model S

Also, VSWR of the antennas is measured under the same condition at Fig.7, and the result is shown in Fig.8. As shown in Fig.8, adding the notch and the tapers, the frequency band width in which VSWR is less than two is extended to $k \fallingdotseq 59\%$ and the center frequency increases because the lowest limit frequency in which VSWR is less than two does not change, virtually.

In order to clear the effect of adding the notch and the the tapers on a radiation pattern, we measure radiation pattern at 1.6GHz which is center frequency of the antenna. The measured results observe in xz-plane and xy-plane are shown in Fig.9 (a)and (b), respectively. Fig.9 (a) is almost similar to Fig.5 (a) so that it is considered that there is no effect




(a) xz-plane (b) xy-plane

Fig.9 Radiation pattern of added notch and taper on element 2

of adding the notch and the papers for radiation pattern of xz-plane. Fig.9 (b) is also similar to Fig.5 (b) except that cross polarization is slightly larger than Fig.6 (b).

### 4.Conclusion

In this paper, the radiation characteristics of the antenna with elements adding a triangular plate, a notch and two tapers have been experimentally examined. From the results, it is shown that the bandwidth ratio of this antenna is 58.6% in the condition of $l_1$=39.0mm, $w_2$=12.0mm, $w_{t1}$= $w_{t2}$=2.0mm, $w_b$=$w_t$=7.0mm, and $l_t$ =2.8mm. It shows that the operational frequency bandwidth of this antenna is wider than the one of the traditional half wavelength dipole antenna. Moreover, the radiation pattern is similar to the dipole antenna. We make it possible to implement the small, thin and lightweight antenna using ultra wide band in mobile communication systems or the ultra wide band radio communication systems. Further, we also think that the thin antenna is used as radiation element of Yagi-Uda antenna with a reflector and some director.

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