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RADIATION CHARACTERISTICS OF NOVEL LINEAR ANTENNA COMPOSED OF DUAL ELEMENTS WITH DIFFERENTIAL LENGTH

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1. Introduction

Recently, the small, thin and lightweight antenna that works in the wide band is required for the mobile communication systems or the ultra wide band radio communication systems. On the other hand, in a two wire transmission line terminated by a open circuit at the end, it is experimentally known that the undesired emission is occurred when the length of the two wires is different each other [1] because the common mode current should be generated in the line. The issues of suppression of this undesired emission have been discussed. The authors focus on the undesired emission generated by the differential length wire and think that two wires arranged appropriately the length and a space between the wires make a new type antenna working by a new mechanism. Currently, we have studied this idea, experimentally and analytically. And we have obtained the antenna working in the bandwidth of 38% that VSWR is two or less, while that of a half wavelength dipole antenna whose elements are thinner than the wavelength is 10 and several percents calculated by the moment method [2]. In this paper, we demonstrate measured characteristics such as input impedance, VSWR and radiation pattern of this antenna.

2. Antenna Structure

Fig.1 shows the configuration of the antenna. It consists of two elements with different length. These elements are placed in the parallel or with the angle at the space d_f. And the center of each element is aligned. The length of short element (element 1) and long element (element 2) is about 1/4 wavelength and 1/2 wavelength respectively. The element 1 is the copper wire soldered directly in the inner conductor of the semi-rigid coaxial cable for feed at one end of element. Further, the element 2 is consisted of the bended semi-rigid coaxial cable and two copper wires soldered in the outer conductor at the bend and the end respectively. The feed point of the element 2 is located at the center side of about 1/4 length from the end, as shown Fig.1, of element 1. Also, the antenna is fed through the SMA connector attached to the end of the coaxial cable.

3. Measurement of radiation characteristics

In order to search for appropriate configuration parameter of the antenna, we measur input impedance, VSWR and radiation pattern of the antenna for the length of the elements L_1, L_2, the space d_f and the angle α between the elements. VSWR and input impedance are obtained from the measurement of the S parameter by the network analyzer. Radiation pattern is measured with the network analyzer in an anechoic chamber.

In order to evaluate a frequency characteristic of the antenna, we define the

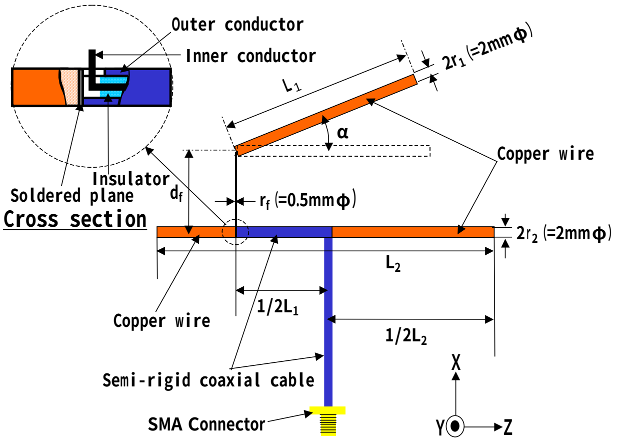

Fig.1 The structure of the antenna

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bandwidth ratio k that VSWR is two or less given by

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

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 The antenna which composed two parallel elements(α =0 °)

The measured results of characteristics of the antenna which elements are parallel are described. The input impedance of the antenna with L_1=40mm, d_f=7.5mm and various L_2 is measured. The results of real parts and imaginary parts are respectively shown in Fig2.1 and 2.2 as a function of frequency. As seen in Fig2.1 and 2.2, they are show that the peak value of the input impedance and its frequency are increase as L_2 decreases. In the case of L_2=90mm, the input impedance is flat and its value is 50Ω over the range from 1350MHz to 1750MHz. It indicates that the impedance matching of the antenna is realized in L_1=40mm and L_2=90mm over comparatively wide range. Also, VSWR of the antenna is measured under the same condition and is shown in Fig.3. As noted immediately, VSWR is small over the wide range of frequency (k 26.3%) in the case of L_2=90mm. Next, the input impedance of the antenna with L_1 =40mm, L_2=93mm and various d_f is measured. The results of real parts and imaginary parts are respectively shown in Fig.4.1 and 4.2. They show that the real part and the rise of imaginary part decrease as d_f decrease. Similarly, VSWR of the antenna is measured and shown in Fig.5. As seen in Fig.5, VSWR is small over the wide range of frequency (k=24.1%) in d_f=7mm. Until now, we decide L_1=40mm, L_2 =90mm and d_f=7mm as the appropriate size of the antennas and use these parameters in following measurement of radiation pattern. The radiation pattern of this antenna is measured at 1.58GHz that is the center frequency. The measured results observed in xz plane and xy plane is shown in Fig.6(a) and (b) respectively. Fig.6(a) shows the radiation pattern looked like the dipole antenna's pattern except for the range of –90 ° < θ <90 ° in the xz plane. The reason of the difference must be asymmetrical structure, connection point between element 1 and 2 of the antenna. Moreover, the level of the cross polarization is smaller than that of the co-polarization in both planes.

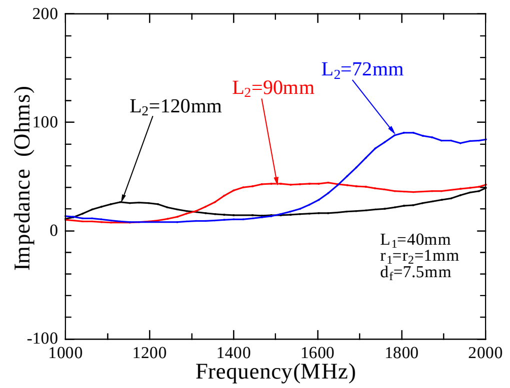


Fig.2.1 A real part of input impedance when L_2 is changed

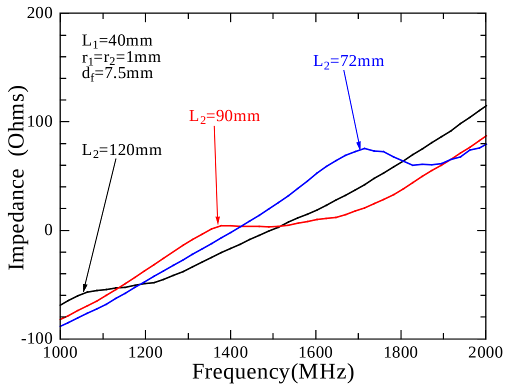


Fig.2.2 A imaginary part of input impedance when L_2 is changed

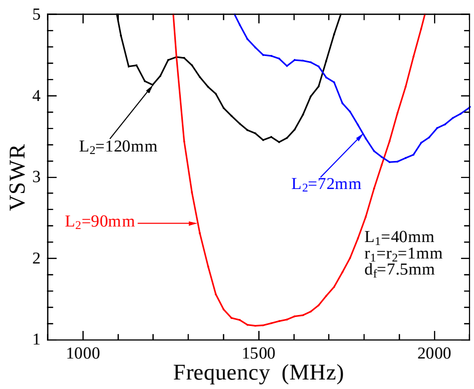


Fig.3 VSWR when L_2 is changed

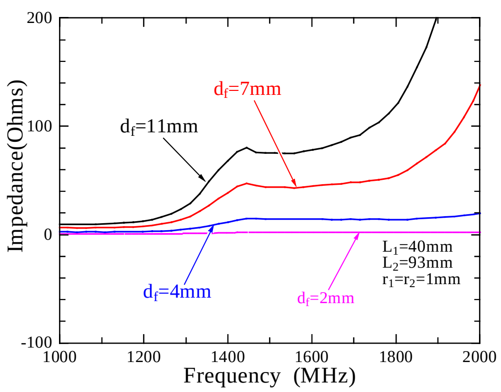


Fig.4.1 A real part of input impedance when d_f is changed

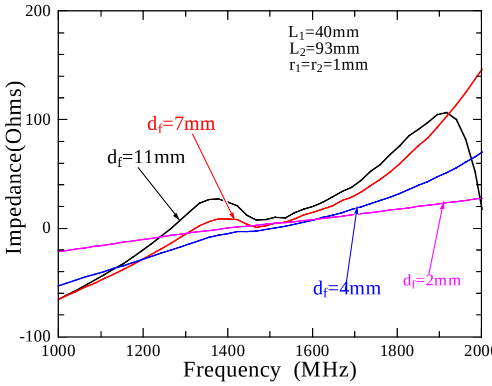


Fig.4.2 A imaginary part of input impedance when d_f is changed

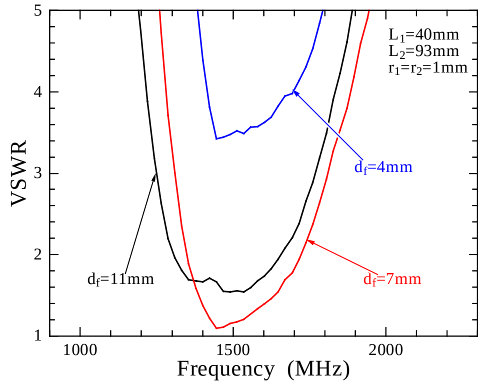
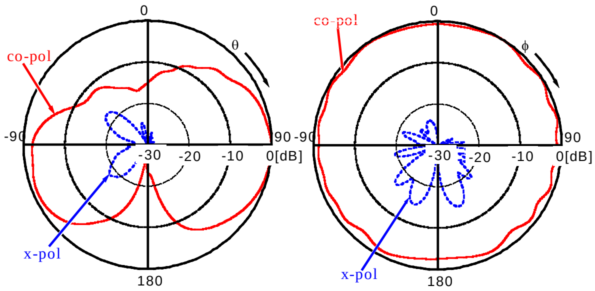


Fig.5 VSWR when d_f is changed



(a) XZ plate (b) XY plate

Fig.6 The radiation pattern

3.2 The antenna which composed two un-parallel elements (α ≠0)

The measured results of characteristics of the antenna which elements are not parallel are described. The input impedance of the antenna of L_2=90mm, L_1=40/cos α (mm), d_f=7mm and various α is measured. The results of real parts and imaginary parts are respectively shown in Fig7.1 and 7.2 as a function of frequency. In Fig7.1, it is shown that the peak value of the input impedance increase as α increase. Also, VSWR of the antenna is measured under the same condition and is shown in Fig.8. In Fig.8, VSWR is small over the wide range of frequency (*k* 33.8%) in α =7.5 °. Next, the input impedance of the antenna with L_1=40.3mm, L_2=90mm, α =7.5 ° and various d_f is measured The results of real parts and imaginary parts are respectively shown in Fig.9.1 and 9.2. They show that the real parts and the imaginary parts decrease as d_f decrease. Similarly, VSWR is measured and shown in Fig.10. As seen in Fig.10, VSWR is small over the wide range of frequency (*k*=32.3%) in d_f=7mm. Here, using the parameters of L_1=40.3mm, L_2=90mm, d_f =7mm and α =7.5 °, we measure radiation pattern at 1.58GHz that is center frequency of the antenna. The measured results observed in xz plane and xy plane is shown in Fig.11(a) and (b) respectively. Fig11(a) also shows that the radiation pattern looked like the dipole antenna's pattern except for the range of –90 ° < θ <90 ° in the xz plane. Moreover, the level of the cross polarization is smaller than that of the co-polarization in both planes, too.

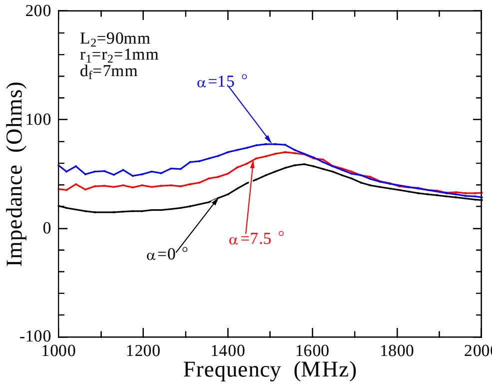


Fig.7.1 A real part of input impedance when α is changed

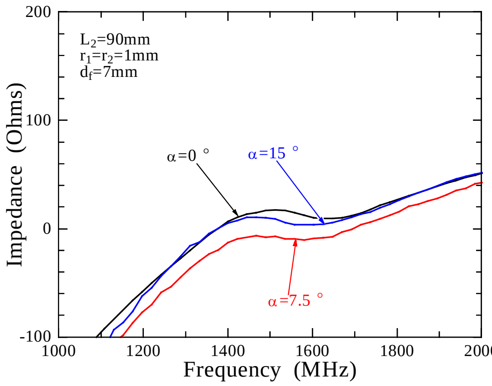


Fig.7.2 A imaginary part of input impedance when α is changed

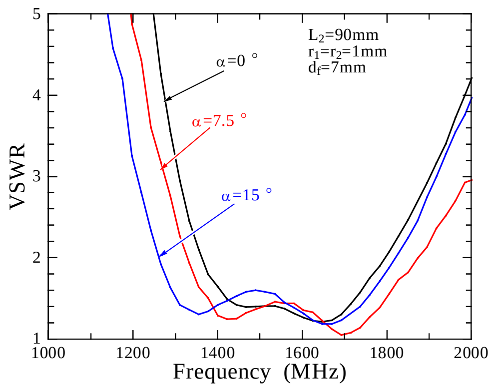


Fig.8 VSWR when α is changed

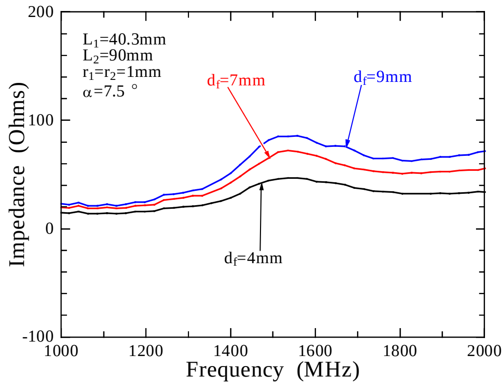


Fig.9.1 A real part of input impedance when d_f is changed

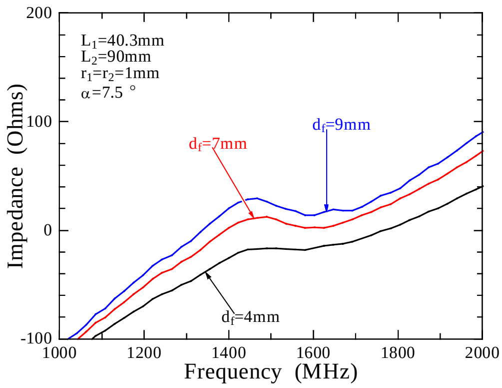


Fig.9.2 A imaginary part of input impedance when d_f is changed

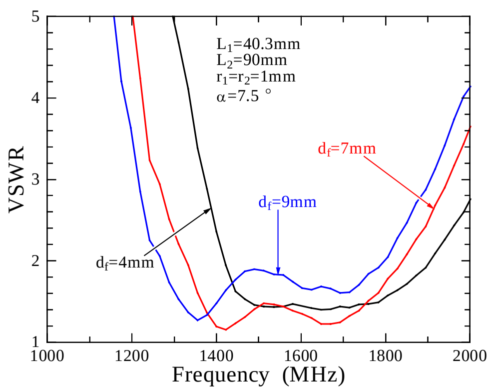
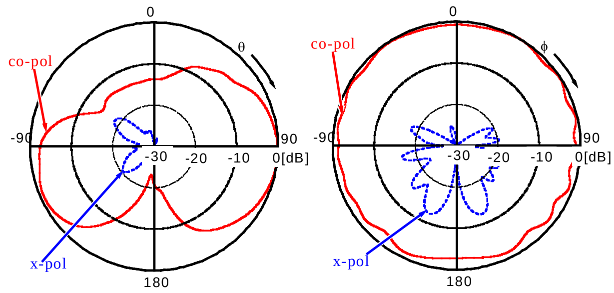


Fig.10 VSWR when d_f is changed



(a) XZ plate (b) XY plate

Fig.11 The radiation pattern

4. Conclusion

In this paper, the radiation characteristics have been examined experimentally for the various size of the element. The results indicate that the bandwidth ratio k of this antenna is 38% in the condition of L_1 =40.3mm, L_2=90mm, d_f=7mm and α=7.5 °. 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 one of the dipole antenna. We obtained the aim to realize the small, thin and lightweight antenna with the wide band radiation characteristics for the mobile communication systems or the ultra wide band radio communication systems. Further, we think that this antenna is used for the radiation element of Yagi-Uda antenna with a reflector and some directors.

References

[1] C. R. Paul, "Introduction to Electromagnetic Compatibility", WILEY, 1992

[2] T.Ishida, et al. "Radiation Characteristics of Linear Antenna composed of Dual Elements with Differential Length", IEICE Spring Conf, March, 2005. (in Japanese)