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Meander Line Antenna Built in Folder-Type Mobile Phone for Digital Terrestrial Broadcasting System

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1. Introduction

The digital terrestrial broadcasting (DTB) will provide new broadcasting service such as high definition television, multichannel service, datacasting and broadcast for mobile terminals, especially for a recent mobile phone. The DTB will replace all the conventional analog TV broadcasting in the near future. Recently, built-in mobile phone antennas for DTB service has been developed for the easy use and in the view point of design, because the DTB for mobile terminals has started in April 2006 in Japan and many hand phones with the function of DTB reception are on the market. The DTB utilizes UHF band in the frequency range from 470MHz to 770MHz and its relative bandwidth required to be more than 48%. Several promising built-in antennas have been proposed [1], however, a space for built-in antenna is very small compared with the wavelength in DTB band. Because the upper part is for the cover of the folder-type phone and is used for the LCD display, and the bottom part usually accommodates the microphone and the keypad. The space for the built-in antenna is at hinge [2] and under key pad. The former is not suitable in the place because of noise effect and the latter size is too small. The antenna loaded inductor with a volume of 2.6 cc was presented in ref. [3], and its VSWR is less than 3 within the range of 500-710MHz. This paper presents a promising internal meander line antenna mounted on dielectric block with impedance matching circuits. By selecting a proper value of the dielectric loss tangent in the dielectric, we obtain improved impedance matching of the antenna over the UHF band. This paper also discusses about the radiation efficiency of the proposed antenna.

2. Antenna Structure

Figure 1 shows a geometry of antenna model used in this paper and Fig. 2 shows the detailed view of built-in antenna. The size of two ground planes are the same, and are selected to have the dimensions of 40×80mm for a practical folder-type mobile phone. In this paper, the DTB antenna is placed at the bottom of lower ground plane and meander line antenna on the dielectric block is used. The number of turn for meander line is adjusted to be N=8 to have a resonance in DTB band. The line width is found to affect effectively the lower band edge and is selected to be 1.6mm for the proposed antenna. The thickness of meander line is 18μmm throughout the paper. For the impedance-matching, meander antenna is short-circuited at the first corner from the feeding and is terminated through a variable capacitor to adjust the electrical length. The dielectric block with relative dielectric constant of 2.2 inserted under the meander line, where the dielectric loss is assumed to be tanδ=0.06. Antenna characteristics are calculated by CST Microwave Studio 2006B.

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3. Meander Antenna Characteristics

Figure 3 shows the calculated reflection characteristics of the proposed meander line antenna by changing the capacitance for the impedance matching. Operating bandwidth covering 585-770 MHz for UHF band reception is obtained by the variable capacitor of C=0.4pF-1.1pF. However, the $|S_{11}|$ is larger than -10dB at the frequency less than 585MHz. Provided the capacitor value and the turn of meander are adjusted, the reflection characteristics are not improved around 470MHz. To improve these frequency characteristics, a dielectric block of ϵ_γ=2.2 is inserted under the meander line. Figure 4 shows the reflection characteristics of the meander line antenna with dielectric block without loss. Though the input characteristics are improved in the frequency range of 595-770 MHz using the variable capacitor of C=0.1pF-0.7pF, the $|S_{11}|$ level is still large for the frequency less than 595MHz and its bandwidth less than -10dB is narrower than the antenna without using dielectric block.

To obtain good impedance matching, the loss is added to the dielectric block. Though, it causes the reduction of radiation efficiency, low $|S_{11}|$ value is important for receiver circuit design. Figure 5 shows the calculated $|S_{11}|$ for antenna with dielectric loss, where its loss tangent is 0.06. By introducing the dielectric loss, the frequency bandwidth is extended to 470-770 MHz that is enough wide for UHF band reception using the variable capacitor of C=0.1pF-1.8pF. The radiation patterns in the zx plane for each frequency of 470, 570, 670, and 770 are shown in Fig.6. They are almost the same radiation pattern as dipole antenna. This shows that the ground plane dose not affect to it, because its electrical length is less than half wavelength in the operating frequency. Figure 7 shows radiation efficiency due to dielectric with or without loss. Radiation efficiency is deteriorated about 4dB by the dielectric loss. The mobile phones are often used in closed state as shown in Fig. 8. The input characteristics of this state is shown in Fig. 9, and its radiation efficiency is shown in Table 1. Radiation efficiency is deteriorated about 4dB in the closed state.

4. Conclusion

This paper presented a novel internal meander line antenna for DTB reception in the frequency range of 470-770 MHz band. The antenna used narrow space of lower ground plane with frequency tunable circuit and dielectric block. We obtained radiation efficiency more than -4dB for loss less dielectric material. In future, we need to decrease number of capacitor for the partical applications, and it is necessary to improve its radiation efficiency.

5. ACKNOWLEDGMENT

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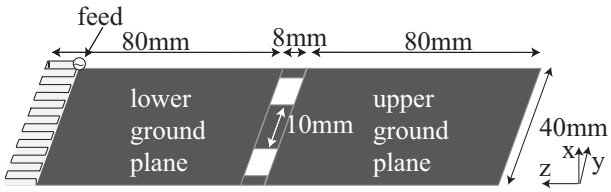

Fig. 1: Configuration of internal antenna for folder-type mobile phone

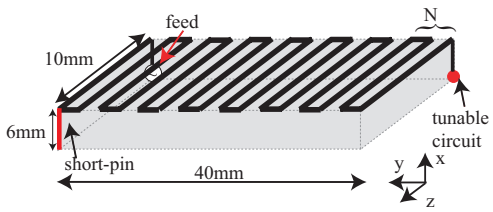

Fig. 2: Detailed view of built-in antenna

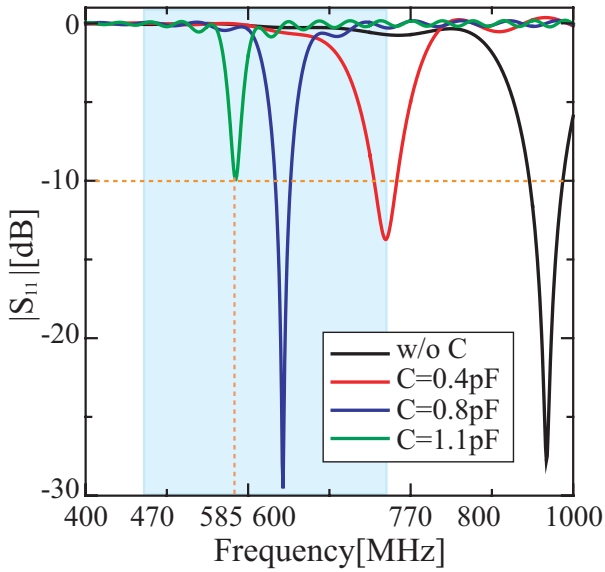

Fig. 3: Reflection characteristics of meander line antenna by changing the capacitance

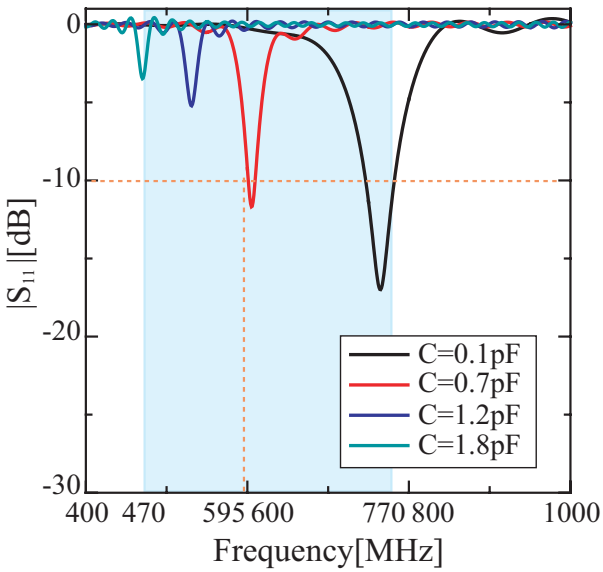

Fig. 4: Reflection characteristics of meander line antenna and dielectric block w/o loss

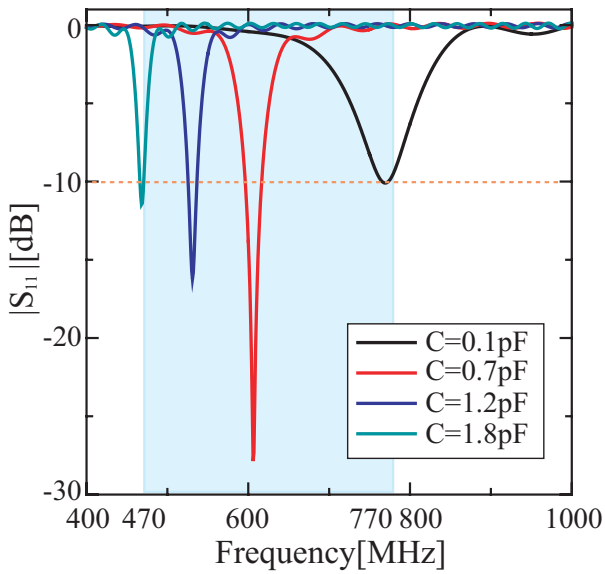

Fig. 5: Reflection characteristics of the meander line antenna and dielectric block w/ dielectric loss

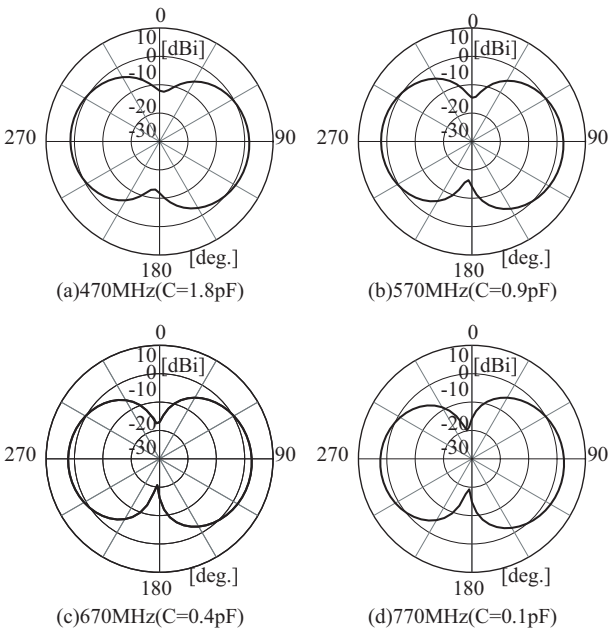

Fig. 6: Radiation patterns in the zx plane

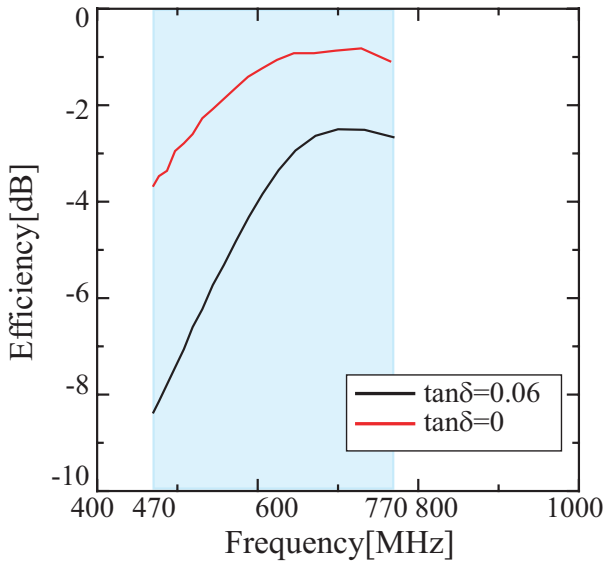

Fig. 7: Radiation efficiency

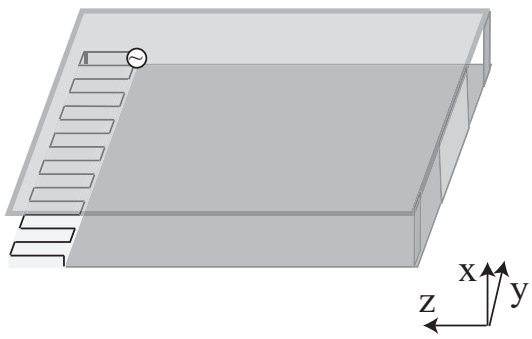

Fig. 8: Configuration of internal antenna for closed state mobile phone

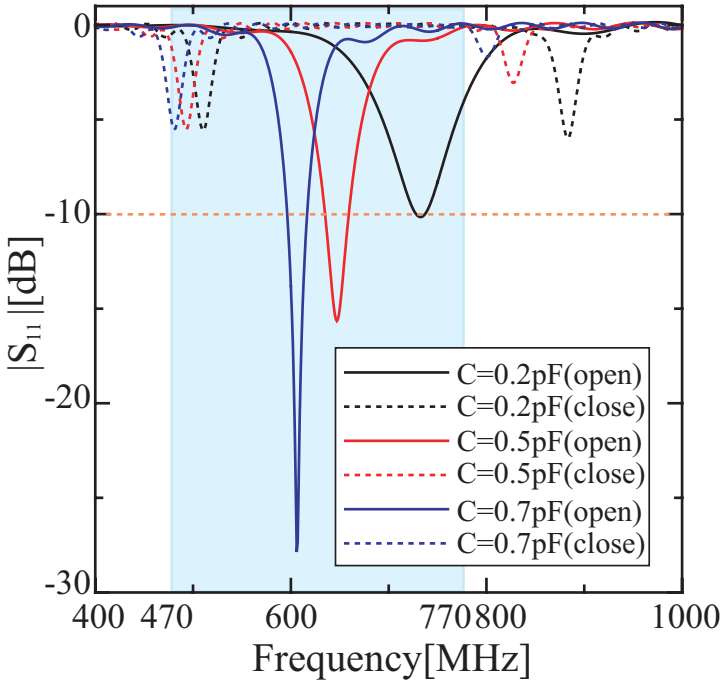

Fig. 9: Reflection characteristics for closed state

Table 1: Characteristic of closed position

	resonance frequency	efficiency
0.2pF(close)	510MHz	-10.19dB
1.4pF(open)	509MHz	-7.06dB
0.5pF(close)	493MHz	-11.31dB
1.5pF(open)	497MHz	-7.44dB
0.7pF(close)	481MHz	-12.04dB
1.7pF(open)	477MHz	-8.24dB