

# A Comparison of Feed Methods for Electrically Small and Low-Profile Meander Line Antennas

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## 1. Introduction

Electrically small and low-profile antennas (ESLA) have been widely studied in recent years [1]-[6]. An antenna which is close to a back conductor can reduce the electrical effects from the backing material when installed on IC chips, human body or any metallic or lossy material. However, typical electrically and low-profile antennas have low radiation efficiency resulting in a difficulty of impedance matching to  $50 \Omega$ .

For designing an ESLA, a capacitive feed (C-feed) technique has been proposed in [7] for a meander line antenna with a length of half-wavelength. Using the C-feed structure, the imaginary part of the input impedance of the antenna can be easily controlled by varying the size of the feed plate which is installed in between the radiating element and ground plane. Furthermore, a modified quarter-wavelength capacitive-feed meander line antenna (QCFMA) has been proposed in [8] for gain improvement satisfying  $ka = 0.435 < 0.5$ ,  $k$ : wave number,  $a$ : radius of a sphere surrounding the antenna.

In this paper, the QCFMA is compared with the same dimension of meander line antenna with an inverted-F antenna structure (IFMA) in order to evaluate the performance of C-feed structure. As a result, QCFMA shows better radiation characteristics than IFMA, and the two fabricated antennas show good agreement with the simulated results.

## 2. Antenna Structure

Fig. 1(a) and (b) shows the top and side view of the C-feed structure (QCFMA). This antenna has a height (the distance between the antenna and the back conductor) of 2 mm ( $0.010\lambda_0 \ll 0.25\lambda_0$ ), and uses RT/Duroid 5880 substrate with a permittivity ( $\epsilon_r$ ) of 2.2 and dielectric loss ( $\tan\delta$ ) of 0.001. The dimension of the substrate and the back conductor are 22.5 mm  $\times$  14 mm ( $0.121\lambda_0 \times 0.075\lambda_0$ ). The meander line has a width of 4.5 mm and shorted at the far end with a total length of around  $\lambda_0/4$ . The metallic feed plate in the figure, which is installed in between the meander line and the back conductor, provides capacitance to the input impedance. The meander line is electromagnetically coupled from the feed plate. The feed plate has a length ( $f_l$ ) of 5 mm and width ( $f_w$ ) of 2 mm for impedance matching. Furthermore, effect of the gap between the two dielectric substrates is considered. The thickness of the gap ( $g$ ) is chosen to 0.4 mm for fabrication.

QCFMA is compared with an inverted-F meander line antenna (IFMA) which is shown in Fig. 2. The dimensions and the shape of the IFMA are the same as those in QCFMA for comparison. The meander line of IFMA is fed as shown in Fig. 2(c), however, a shorted stub is necessary for impedance matching as shown in the figure since the feed structure does not give sufficient inductivity to cancel the capacitance at the resonance frequency of such a low-profile meander line antenna. The shorted stub has a length in the x direction ( $s_l$ ) of 2 mm. Effect of the gap between the two dielectric substrates is considered and the  $g$  is chosen to 0.4 mm as similar to QCFMA.

## 3. Simulated and measured results

The simulated results of antenna characteristics of QCFMA and IFMA are shown in Fig. 3. The QCFMA and IFMA resonate at approximately the same frequency as shown in Fig. 3(a). In both antennas, the structure with the gap  $g$  of 0.4 mm has a higher resonance frequency compared with when there is no gap. It is due to decrease in the capacitance between the meander line and the back conductor. The radiation efficiency of QCFMA is higher than that of IFMA by around 31% at the resonance frequency. It is also noticed that the radiation efficiency of the antennas with the gap is better than when there is no gap. Whether there is or not the gap, the radiation efficiency of QCFMA is higher than IFMA.

The two antennas are fabricated and measured. Table 1 shows the simulated and measured results of radiation efficiency at the resonance frequency. The radiation efficiency of the antenna is estimated with the Wheeler cap method [9]. In both antennas, the measured radiation efficiency is close to the simulated results. Fig. 4 shows the radiation patterns in  $y$ - $z$  and  $x$ - $z$  plane of QCFMA and IFMA. The directivity of these antennas in the  $y$ - $z$  plane is different between QCFMA and IFMA.

## 4. Conclusion

The QCFMA shows higher radiation efficiency than IFMA. Especially, the radiation efficiency of the QCFMA is improved very sensitively by making a small gap (air layer with a thickness of  $g=0.4$  mm) compared to that of IFMA. These planar shape antennas are very useful to install devices with limited space. Therefore, the antenna can find its applications in mobile terminals and RFIDs.

## 5. Acknowledgement

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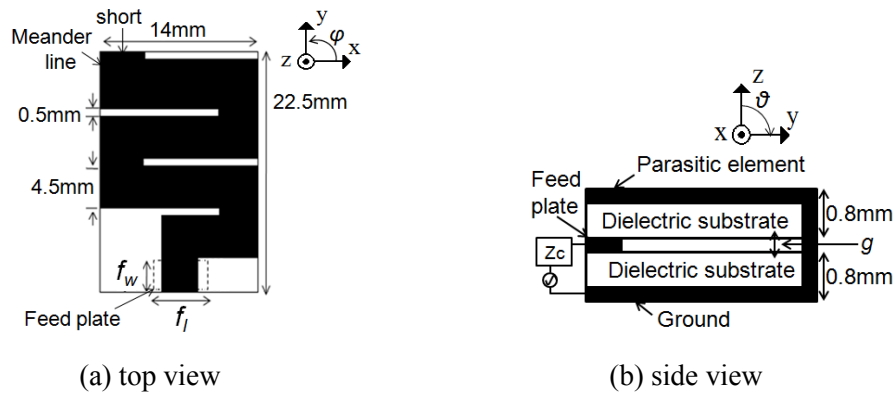


Figure 1: Capacitive feed structure (QCFMA)

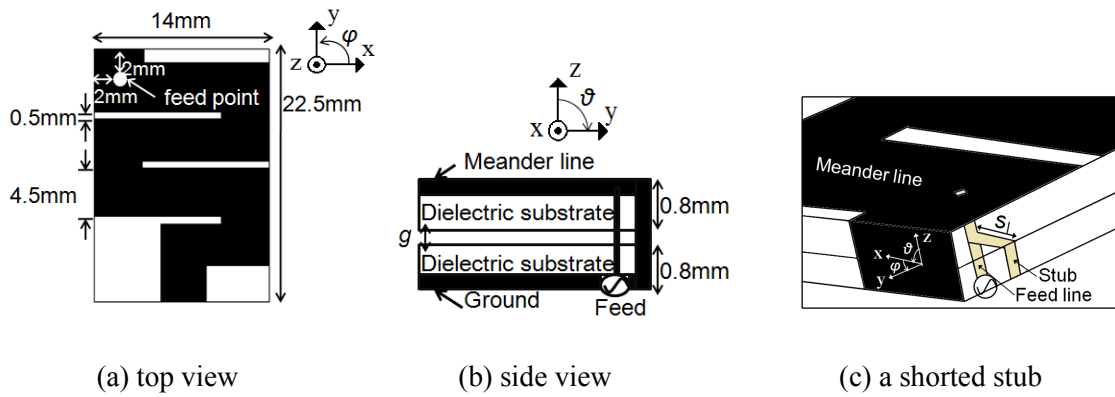


Figure 2: Inverted-F meander line antenna (IFMA)

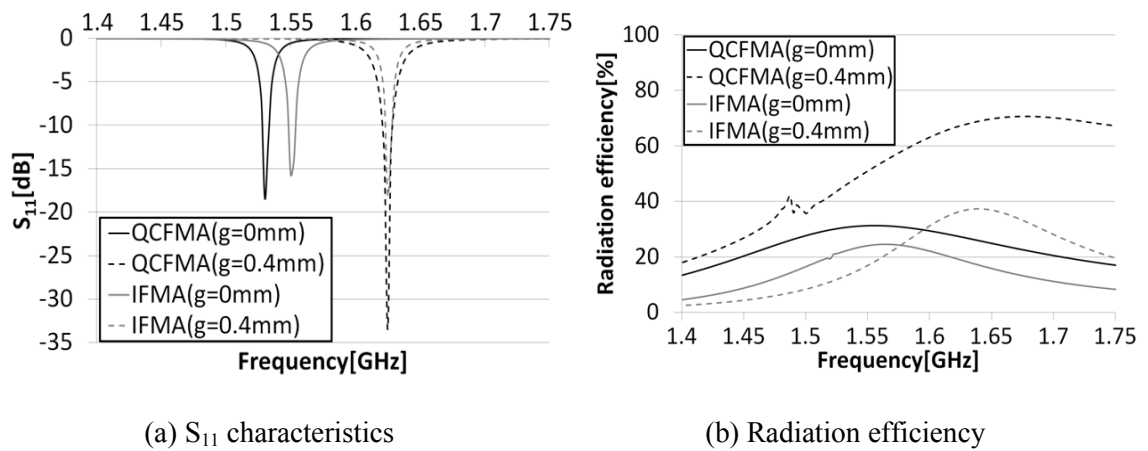


Figure 3: Comparison of the antennas (Simulation)

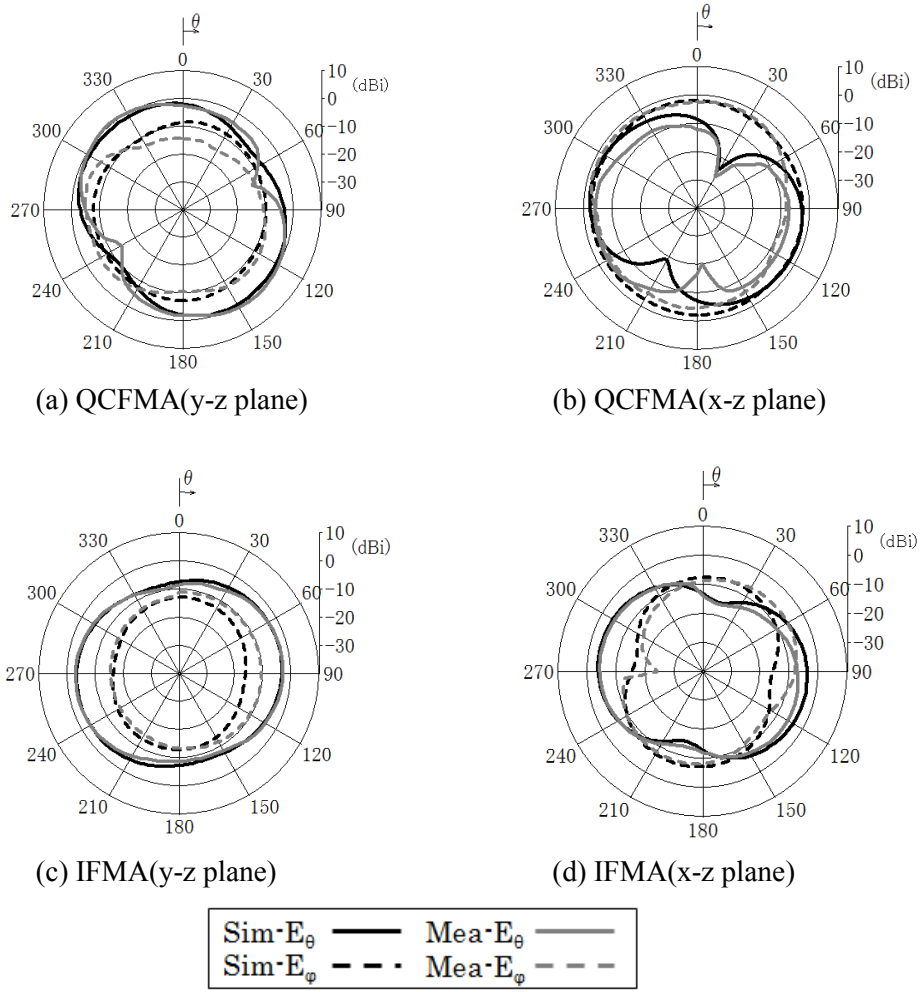


Figure 4: Simulated and measured radiation patterns in y-z plane and x-z plane

Table 1: Simulated and measured radiation efficiency at the resonance frequency ( $g=0.4$  mm)

	Resonance frequency[GHz]	Radiation efficiency[%]
QCFMA(Sim)	1.63	67.28
QCFMA(Mea)	1.56	65.78
IFMA(Sim)	1.63	36.48
IFMA(Mea)	1.57	31.02