

A Small and Low Profile Meander Antenna Using Capacitive Feed Structure

#Kazuki Ide¹, Takeshi Fukusako²

^{1,2}Dept. of Computer Science and Electrical Engineering, Kumamoto University
2-39-1, Kurokami, Kumamoto, 860-8555, Japan
¹ide@st.cs.kumamoto-u.ac.jp, ²fukusako@ieee.org

1. Introduction

Small and low profile antennas with back reflector have been widely studied in recent years, so as to reduce the electrical effects from the backing material when the antenna is installed on IC chips, human body or on any metallic or lossy material [1], [2]. In low profile linear antennas with back conductors [3], [4], the real part of the input impedance becomes zero on most frequencies other than at the parallel resonant frequencies, when the distance between the linear antenna and back conductor is smaller than quarter wavelength. At a parallel resonance frequency, there is a steep transition in the imaginary part of impedance from a very large positive value to a large negative value. Therefore, it is usually difficult for such antennas to operate at the parallel resonance [1], [5]. Using meander line and incorporating capacitances are effective to make electrically small antennas [6], [7] to operate at a serial resonance frequency. But the leakage current existing on the outer conductor of a coaxial cable still causes drastic changes in antenna characteristics [8] when the feed is unbalanced.

A small and low profile antenna using a capacitive coupling with the back conductor is presented in [5] so as to operate at a serial frequency using the electrically small and low-profile structure. However, the coupling terminal with small area easily generates the leaky current on the feeding coaxial cable unless a ferrite choke on the cable is used.

This paper proposes a novel feed structure using a capacitive feed (C-feed) technique. A metallic feed plate placed in between the back metal (ground plane) and the meander line provides capacitance to the input impedance. The meander line, which is the radiating element, is electromagnetically coupled from the feed plate. The effect of CPW feed and C-feed on the antenna is discussed by simulated and measured results.

2. Design and Structure

2.1 Antenna with Coplanar Wave Guide (CPW) Feed

Fig. 1(a) and (b) show the front and cross sectional view of the offset CPW fed meander line antenna. The antenna uses RT/Duroid 5880 substrate with a thickness of 1.6 mm, permittivity (ϵ_r) of 2.2 and dielectric loss ($\tan\delta$) of 0.001. The substrate dimension is fixed at 22.5 mm \times 14 mm ($0.075\lambda_0 \times 0.047\lambda_0$) and satisfies the condition of electrically small antennas ($ka = 0.3 < 0.5$). The meander line has a width (W_m) of 1 mm and spaced (W_d) 0.5mm between the adjacent lines. The ground planes (G_p) of the CPW, have a length (gl_{co}) of 3 mm and width (gw_{co}) of 1 mm, provides capacitive coupling with the back conductor. The imaginary part of the input impedance of the antenna can be controlled by varying the gl_{co} . The equivalent circuit is shown in Fig.1(c).

2.2 Antenna with Capacitive Feed (C-feed)

Fig. 2 (a) and (b) show the front and cross sectional view of the offset C-feeding meander antenna. The antenna has a thickness of 2 mm ($ka = 0.37$), the ground planes (G_p) of CPW are removed from the antenna, and a metallic feed plate is installed in between the meander line and the back conductor. The back conductor, which acts as the ground plane, is 22.5 mm \times 14 mm. The meander line has the same dimensions as in the CPW feed antenna. The feed plate has a length (fl_c) of 14 mm and width (fw_c) of 2 mm. The imaginary part of the input impedance of the antenna can be controlled by varying the fl_c . The equivalent circuit of the antenna is shown in Fig. 2 (c).

3. Results

The structure is simulated using HFSS 10.1. Fig. 3 (a) and (b) show the characteristics of imaginary part of the input impedance, for different values of ground plane length (gl_{co}) of CPW feed antenna in Fig. 1, without and with an SMA connector. For many applications it is required to control the imaginary part of the input impedance so as to maintain a good impedance matching. Fig. 3 (a) shows that the input impedance can be controlled by varying gl_{co} when the antenna does not have an SMA connector. But when the antenna is connected to an SMA connector, Fig. 3 (b) shows that it is difficult to control of the impedance characteristics, since the antenna ground is much smaller than the ground of the connector.

The input impedance characteristics of the C-feed antenna for different values of feed plate length (fl_c) are shown in Fig. 4. The imaginary part of the input impedance can be easily controlled by varying fl_c even with the connector, because the antenna has a large ground plane.

The simulated current distribution on the outer surface of the coaxial cable is shown in Fig. 5 (a) and (b) for CPW and C-feed respectively. The feed is given at the far end of the coaxial cable. The CPW feed antenna shows large leakage current compared to the C-feed antenna. The gain characteristics of both antennas are shown in Fig. 6 (a) and (b). Fig. 6 (a), for CPW feed, shows that the antenna has high gain when connected to a coaxial cable because the signal radiated from the coaxial cable contributes to the antenna gain. But, the maximum gain of the C-feed antenna is the same even in the presence of coaxial cable.

In Fig. 7, the measured S11 characteristics of the CPW feed antenna with and without touching the coaxial cable by a hand, presented show that the characteristics is very sensitive. But the C-feed structure shows stable S11 characteristics (Fig. 8 (a)) even if the coaxial cable is touched. The simulated and measured results of realized gain of the C-feed structure are presented in Fig. 8 (b). The simulated maximum realized gain is -9.8 dBi and measured gain is -13.9 dBi.

4. Conclusion

Small and low profile antennas with $ka=0.3, 0.37$ are simulated, fabricated and measured using CPW feed and C-feed respectively. The proposed C-feed antenna gives a good impedance matching characteristic avoiding the leakage current on the unbalanced feed. This antenna can find its application in RFID and mobile terminals.

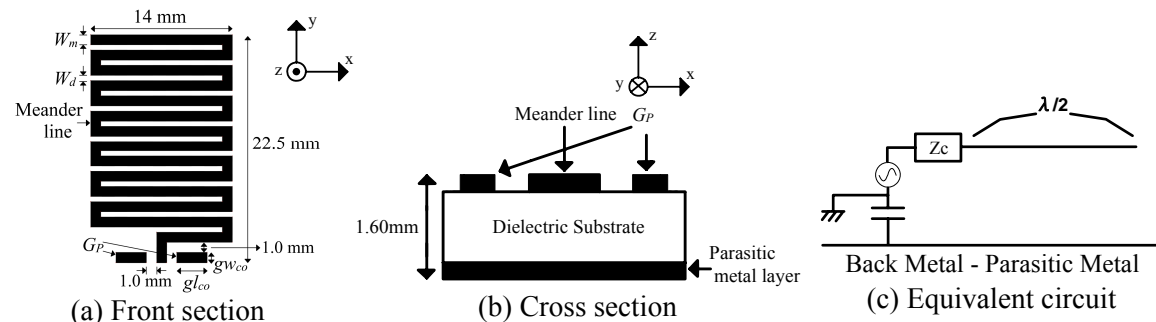


Figure 1. Proposed a small and low profile antenna using CPW feed

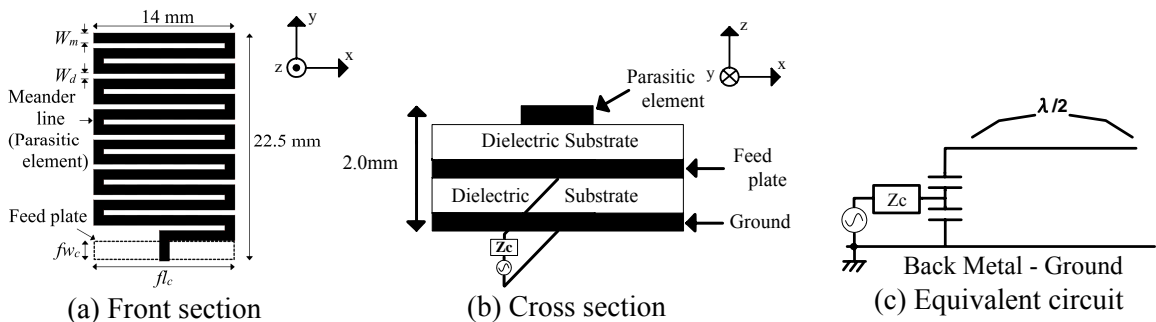


Figure 2. Proposed a small and low profile antenna using C-feed

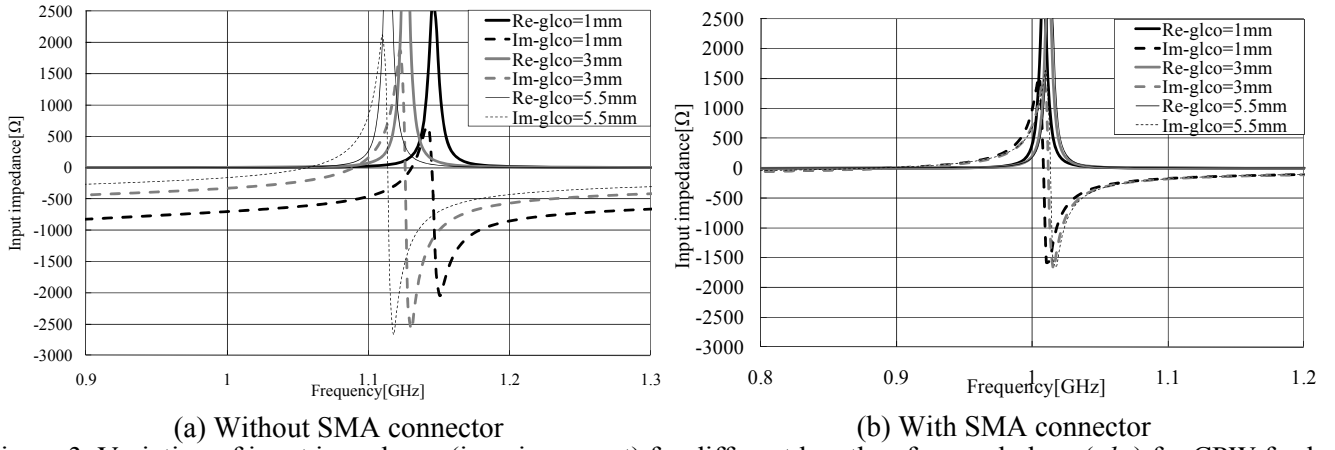


Figure 3. Variation of input impedance (imaginary part) for different lengths of ground plane (g_{lco}) for CPW feed

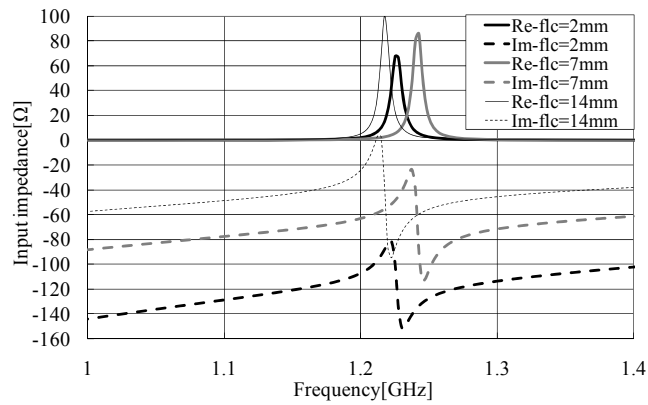


Figure 4. Variation of input impedance (imaginary part) for different lengths of feed plate (l_c) for C-feed with SMA connector

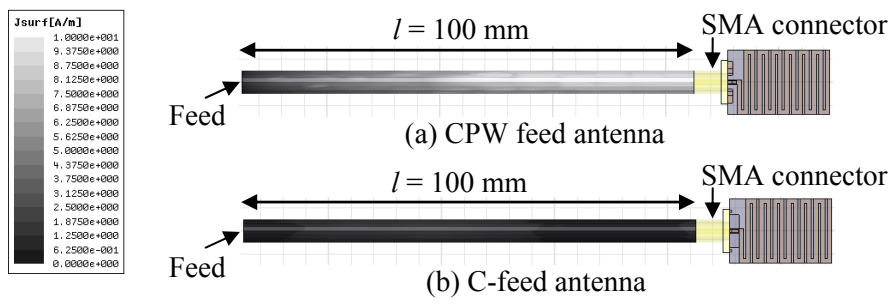


Figure 5. Current distribution on the outer surface of the coaxial cable

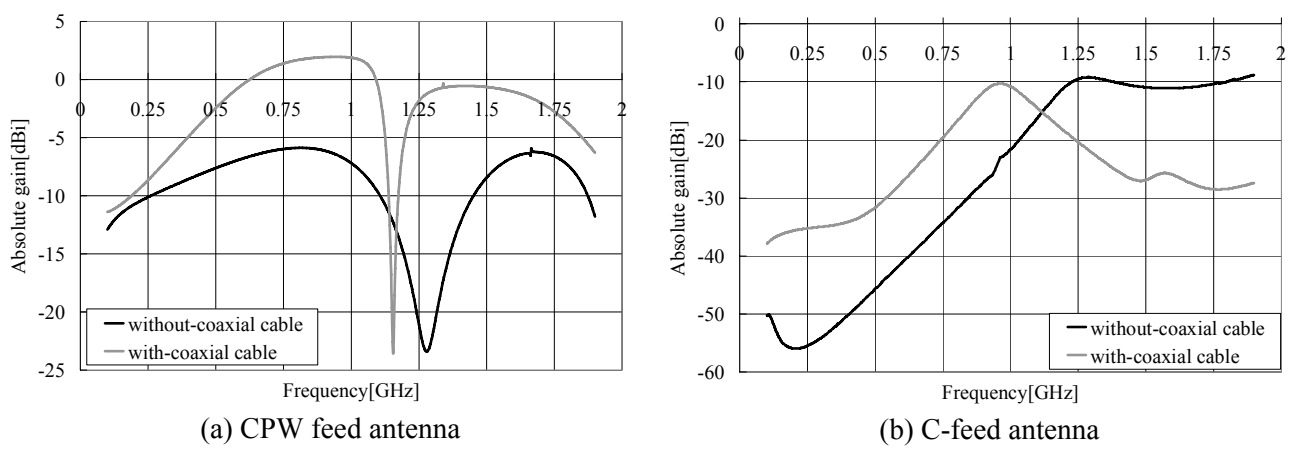


Figure 6. The simulated absolute gain characteristics

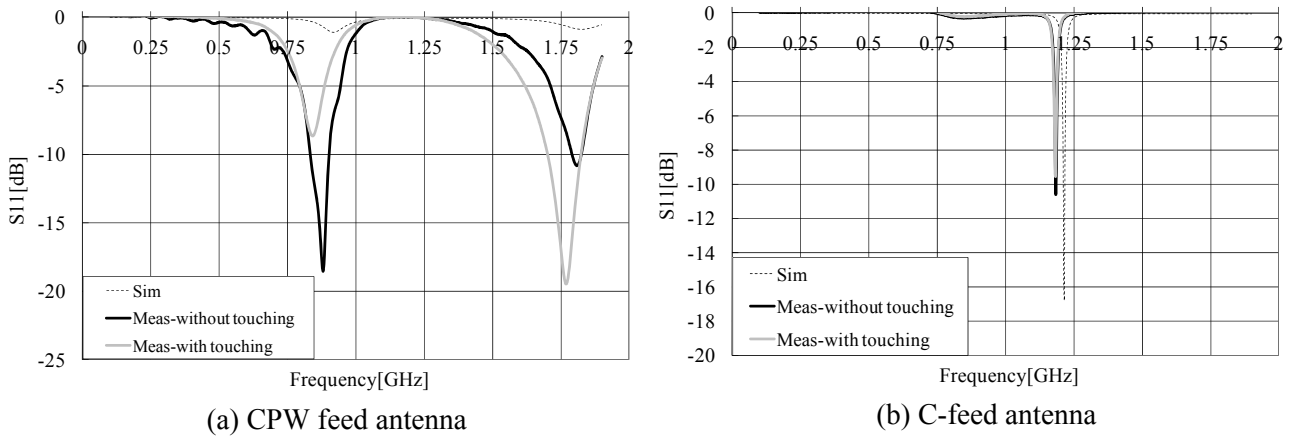


Figure 7. S11 characteristics with and without touching the coaxial cable

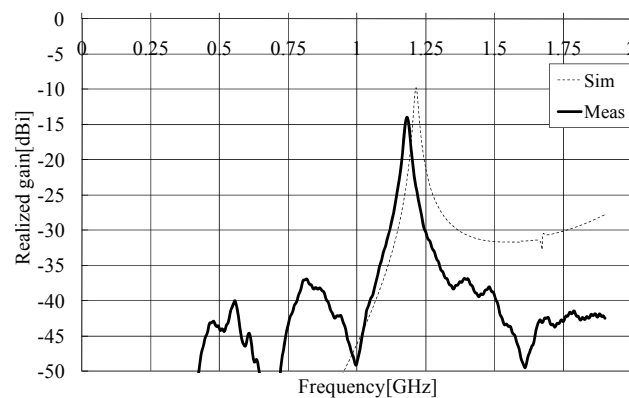


Figure 8. Realized gain of C-feed antenna

References

- [1] S.R. Best, "A discussion on the properties of electrically small self-resonant wire antennas", *IEEE Antennas Propag. Mag.*, 46. 6, pp.9-22, Dec 2004
- [2] K.V.S. Rao, P.V. Nikitin, and S.F.Lam, "Antenna design for UHF RFID tags: a review and a practical application", *IEEE Trans. Antennas Propag.*, 53. 12, pp.3870-3876, Dec 2005
- [3] T.Tsukiji and Y. Kumon, "Modified transmission line type antennas for mobile communication", *IEICE Trans. Commun.* E75-B, 8, pp.775-780, Aug. 1992
- [4] A. Thumvichit and T. Takano, "Ultra low profile dipole antenna with a simplified feeding structure and a parasitic element," *IEICE Trans. Commun.* E89-B, 2, pp.576-579, Feb. 2006
- [5] T. Terada, K. Ide, K. Iwata, and T. Fukusako "Design of a small, low-profile print antenna using a peano line," *Microw. Opt. Technol. Lett.*, 51, 8, pp.1833-1838, Aug. 2009
- [6] W. Choi, S. Kwon, and B. Lee, "Ceramic chip antenna using meander conductor lines" *Electron Lett.*, 37, 15, pp.933-934, July 2001
- [7] C.R. Rowell and R.D. Murch, "A capacitively loaded PIFA for compact mobile telephone handsets" *IEEE Trans. Antennas Propag.*, 45. 5, pp.837-842, May 1997
- [8] S.Sekine. and H. Shoki, "Characteristics of T-type monopole antenna with parallel resonance mode" *IEICE Trans.*, J86-B, 2, pp.200-208, Aug. 2003.(in Japanese)