Size reduction of microstrip-fed slot antenna by inductive and capacitive loading

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1. Introduction

Microstrip-fed slot antennas are useful in broad range of applications owing to their low profile, low cost, light weight, and ease of integration with other active components. Especially, there has been considerable interest in developing compact slot antennas for mobile communication systems. There are several techniques that can be used to reduce the size of slot antennas. Including : use of capacitive loading [1], inductive loading [2], increase of the electrical length [3], and change of antenna's topology [4]. However, the first two reactive loading techniques have a little effect on the size reduction, and the other techniques have a relatively small bandwidth.

In this paper, we present new structures of slot antenna with capacitive loading and inductive loading simultaneously. One of designs has 52.9% size reduction of slot length compared to the conventional slot antenna and 2.8% impedance bandwidth.

2. Antenna design and Theory

The proposed antenna structures are shown in Fig. 1. Dumbbell shape of slot provides an inductive loading effect ΔL at the edge of the slot, and inter-digital capacitor shape (type A) or cantilever shape (type B) of center of slot provides a capacitive loading effect ΔC.

Larger inductive loading is obtained by increase of the dumbbell length (*D)* and width (*V)*, and larger capacitive loading is obtained by decrease of *G, W, H* and increase of *U* with some limit.

Since the equivalent circuit taken at the center of the slot antenna is represented parallel resonant circuit as shown in Fig. 2, the resonant frequency is determined by the equivalent L and C. Therefore, larger *D, V, U* and smaller *G, W*, *H* result in larger equivalent L, C, and lower resonant frequency.

The duroid 5880 substrate with the dielectric constant of 2.2 and thickness of 31mils has been used. The slot length (*L)*, and width (*S)* are fixed by 13mm and 1mm respectively, and the dumbbell length (*D)*, and width (*V)* are fixed 5mm for the comparison of the resonant frequency for each design.

3. Results

To verify the effects of the proposed structures on the size reduction and antenna performances, input return losses and radiation patterns are simulated

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using CST MWS and Ensemble, measured, and compared to conventional slot antenna.

Table 1 compares the resonant frequency, bandwidth, and size reduction rates of the conventional slot antenna, dumbbell shape slot antenna, and proposed antennas. The size reduction rates are calculated by decrease rates of resonant frequency. In general, the inter-digital capacitor has a smaller capacitance compared with overlay capacitor. Therefore, type B antenna has a more size reduction rate than type A.

The simulated and measured antenna input return losses and radiation patterns are shown in Fig. 3 and Fig. 4. The measured return loss agrees well with the simulated result, and the radiation patterns are similar to the conventional one along the E-plane and H-plane.

4. Conclusion

New structures of size-reduced slot antenna have been proposed. By using the inductive and capacitive loading, one of the proposed antennas has been reduced the length of slot by 52.9% and had 10dB bandwidth of 2.8% with the same radiation pattern as the conventional slot antenna. These antennas can be modified to a frequency tunable slot antenna by using the variable capacitor or tunable capacitor using MEMS process.

5. Acknowledgement

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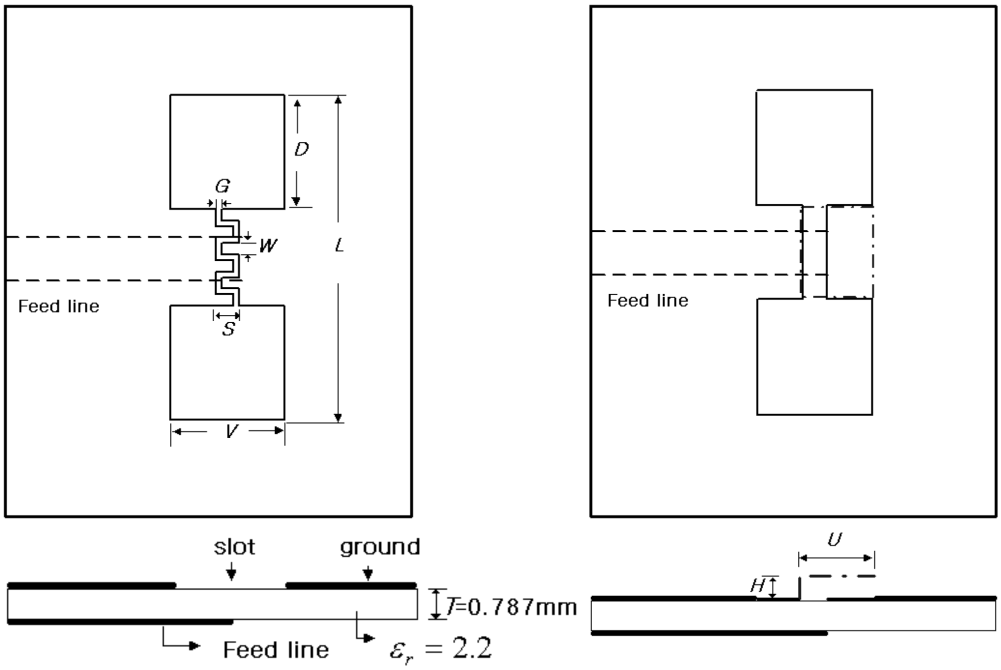


(a) type A (b) type B

Fig. 1 Structures of the proposed antennas

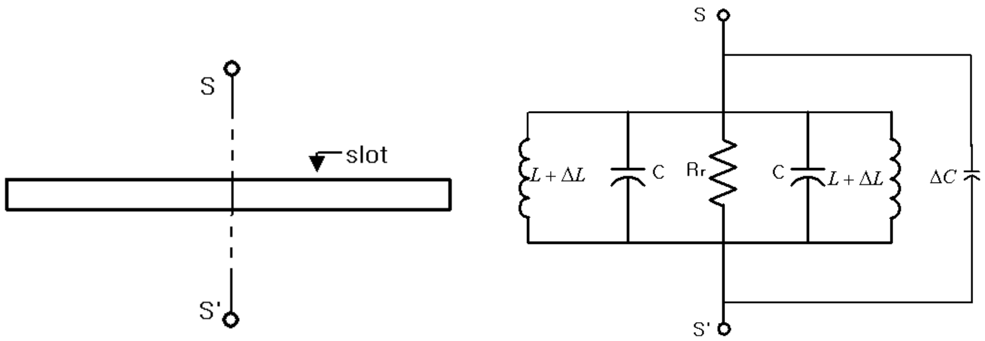


Fig. 2 Equivalent circuit of the center-fed slot

Table 1. Comparison of measured antenna performances

Antenna type	Resonant frequency (GHz)	10dB Bandwidth (%)	Size reduction (%)
Conventional	7.98	4.8	-
Dumbbell shape	5.86	4.8	26.6
Type A	4.72	2.9	40.9
Type B	3.76	2.8	52.9

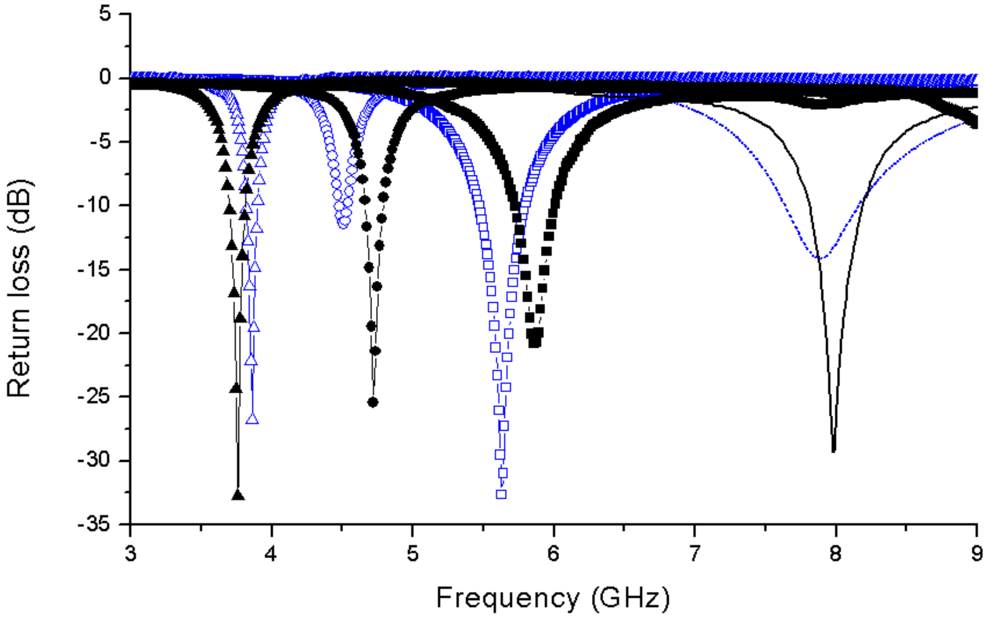
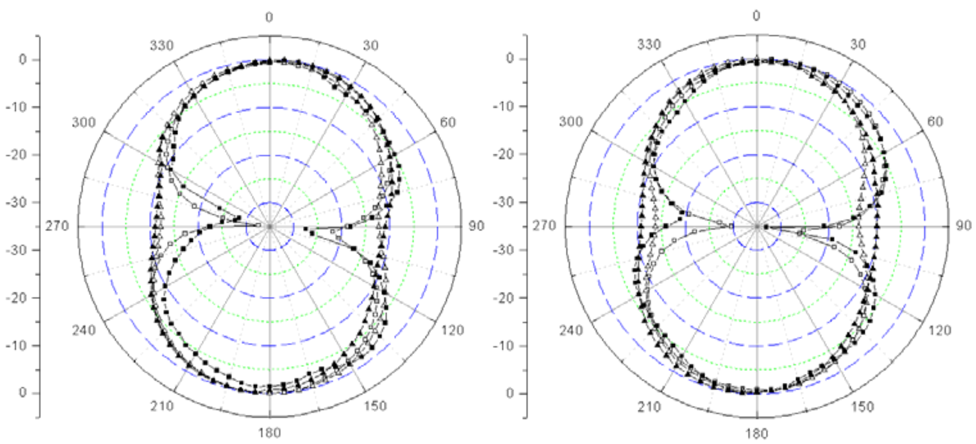


Fig. 3 Input return losses



(a) type A

(b) type B

Fig. 4 Radiation patterns