A Study on Miniaturization of Bow-Tie Antenna with Folded Elements

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1. Introduction

Bow-tie antenna is one of wideband antennas [1]. It has been reported that the bow-tie antenna has been miniaturized by adding folded elements [2]. In this paper, it is shown that bending the bow-tie antenna with folded elements is effective method for miniaturization. The bent bow-tie antenna with folded elements can be more miniaturized than conventional bow-tie antenna with folded elements, while maintaining the broadband characteristic.

2. Antenna Structures

We have designed a conventional bow-tie antenna to obtain 200 Ω matching from around 600 MHz (VSWR≤2). Figure 1 (a) shows the conventional bow-tie antenna. The lowest operating frequency (f_L) (VSWR≤2) is 540 MHz. To downsize the antenna area, it is bent along x axis. Figure 1 (b) shows the bent antenna. The height of the antenna is h. Additionally, folded elements are added to the bent antenna. The width of the folded element is 3 mm. Figure 1 (c) and (d) show the bent bow-tie antenna with one folded element and two folded elements, respectively. The electromagnetic simulator FEKO based on the *Method of Moment* (MoM) is used in the analysis.

3. Simulation Results

3.1 Impedance characteristics

First, the height of the bent antenna without folded elements is changed from 5 mm to 30 mm. Figure 2 shows VSWR characteristics of the antennas. When h is 5 mm, f_L goes up to 840 MHz. f_L lowers when h increases. When the h is 30 mm, the VSWR becomes about the same level of the conventional antenna. All VSWRs maintain broadband characteristics.

Next, when h is fixed to 5 mm, folded elements are added to the bent bow-tie antenna. Figure 3 shows VSWR characteristics of the bent antenna with zero, one and two folded elements. f_L of the bent antenna with folded elements lowers as well as the unbent bow-tie antennas. The f_L of the bent antenna with one folded element and two elements are 360 MHz and 340 MHz, respectively. These mean that the areas of the antenna with one folded element and two elements can be reduced to 44 % (= $(360/540)^2$) and 40 % (= $(340/540)^2$), respectively in order to obtain the same f_L of the conventional bow-tie antenna. Comparing the conventional antenna with the bent antenna when h=5 mm, the bent antenna area is reduced 49% (=(117.5 x 320)/(240 x 320)). Equally, comparing conventional bow-tie antenna with miniaturized bent bow-tie antenna with folded elements, the area of the bent bow tie-antenna with one folded element and two folded elements are 22 % (=0.49 x 0.36) and 20 % (=0.49 x 0.32), respectively. VSWR ≤ 2 with two folded elements is obtained from 340 MHz to 920 MHz (92 %)

3.2 Current Distributions

The current distributions of the bent bow-tie antennas when *h* is 5 mm are compared with the unbent bow-tie antennas. Figures 4 and 5 show the current distributions of the bow-tie antenna without folded element and with two folded elements at 600 MHz, respectively. When the bow-tie antenna is bent and the folded elements are added, the current distribution on the bent bow-tie antenna edges increases as well as the case of the unbent bow-tie antenna. It is considered that this is the reason why f_L with folded elements is lower than that without folded element. On the edge of the bent antenna without folded element, the current is smaller than that of conventional bow-tie antenna. This is considered to be the influence on the higher f_L of the bent antenna. On the edge of the bent antenna with two folded elements, the current distribution increases as well as the case of the unbent bow-tie antenna with folded elements. Therefore, when conventional bow-tie antenna is bent and folded elements are added, the antenna can be miniaturized while maintaining broadband characteristic.

3.3 Radiation Patterns

Figure 6 shows radiation patterns of the conventional bow-tie antenna with two folded elements and the bent antenna with two folded elements at 600 MHz. The bent antenna isn't symmetrical along x axis. Thus, the radiation pattern of the bent antenna with two folded elements isn't similar to that of the unbent antenna with two folded elements. In the operation band with VSWR $\leq$ 2, when the frequency goes higher, the difference between radiation pattern of the bent antenna and that of the unbent antenna on xy plane and zy plane increases.

4. Conclusion

In this paper, we have studied more miniaturized bow-tie antenna with folded elements by bending it. The bent bow-tie antenna maintains broadband characteristics. However, when the height *h* is lower, the lowest operating frequency (VSWR$\leq$2) goes to higher. On the other hand, when the folded elements are added to the bent antenna, the lowest operating frequency lowers while the height of antenna is kept to 5 mm. When the height *h* is 5 mm and two folded elements are added, the area of the bent bow-tie antenna with two folded elements can be reduced to 20 % of conventional bow-tie antenna.

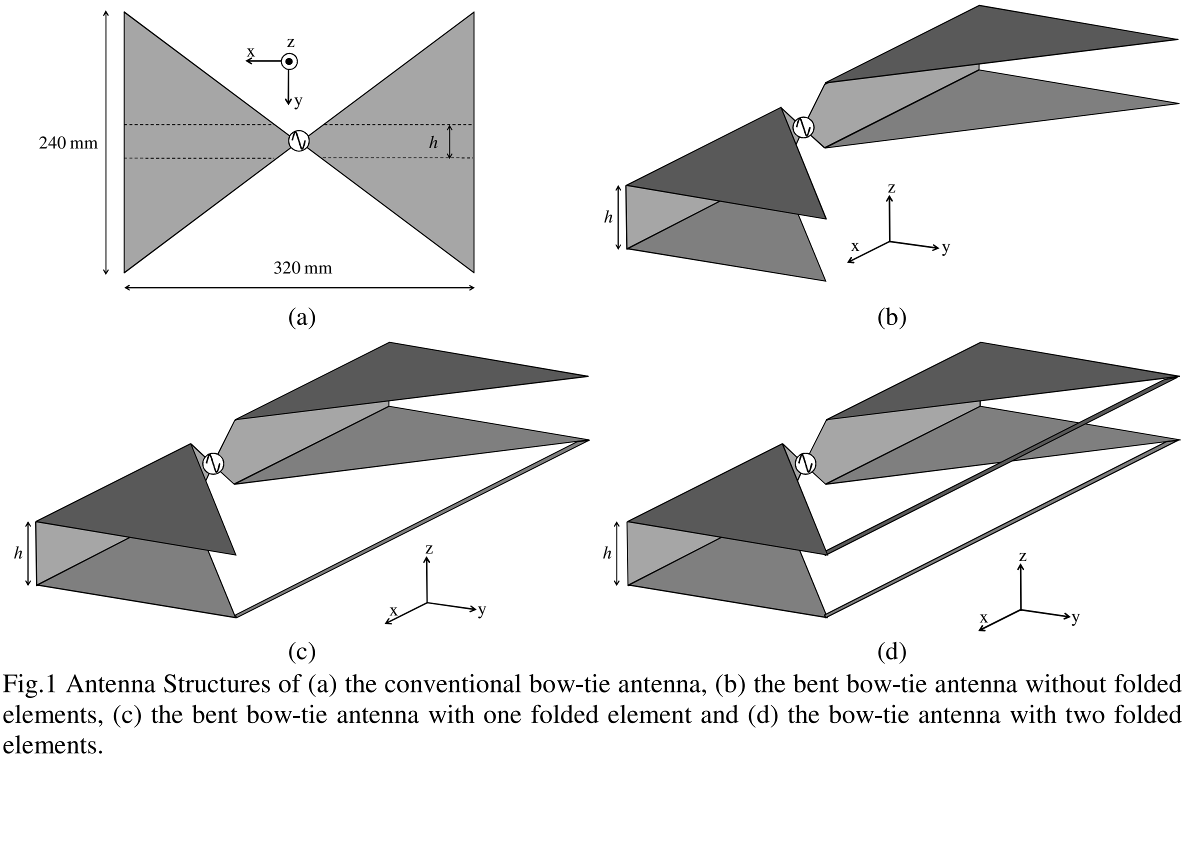


Fig.1 Antenna Structures of (a) the conventional bow-tie antenna, (b) the bent bow-tie antenna without folded elements, (c) the bent bow-tie antenna with one folded element and (d) the bow-tie antenna with two folded elements.

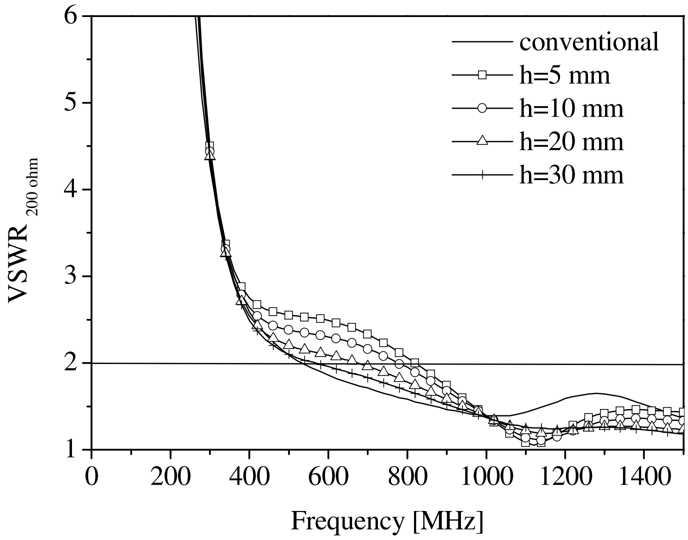


Fig.2 Simulated VSWRs of bent bow-tie antennas without folded elements (Normalized by 200 Ω)

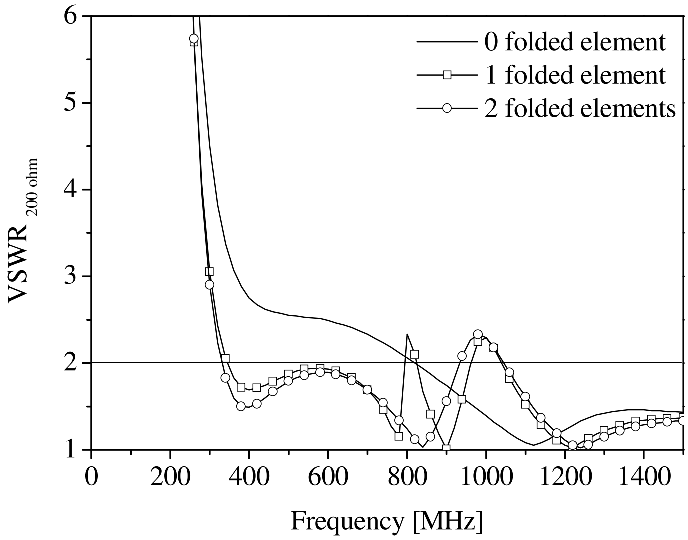
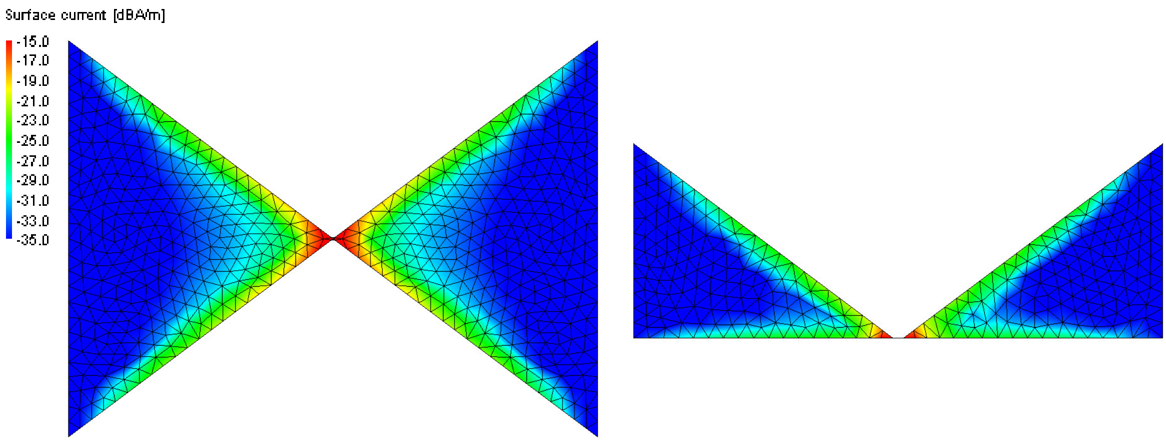
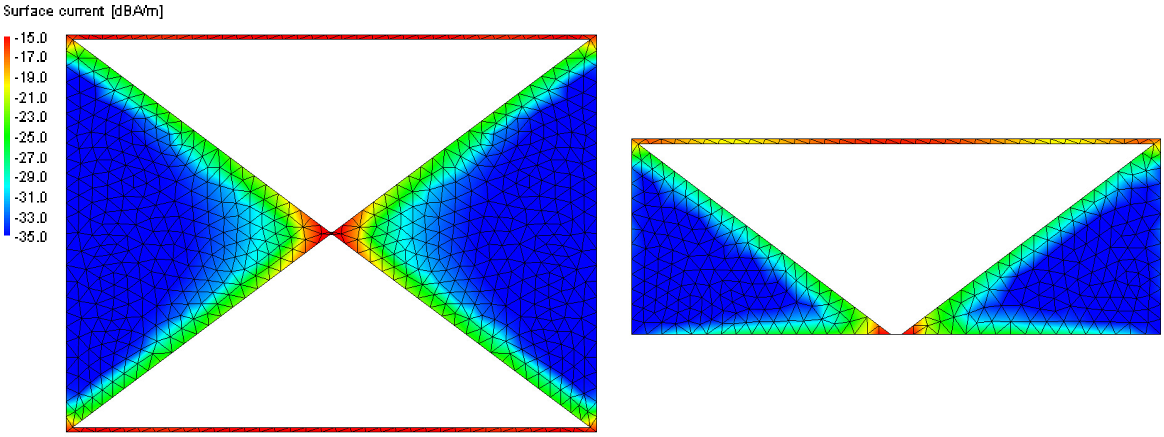


Fig. 3 Simulated VSWRs of bent bow-tie antennas with zero, one and two folded elements (Normalized by 200 Ω, h = 5 mm).



(a) (b)

Fig.4 Current distributions of (a) conventional bow-tie antenna and (b) bent bow-tie antenna (*h*=5mm) at 600 MHz.



(a) (b)

Fig.5 Current distributions of (a) conventional bow-tie antenna with two folded elements and (b) bent bow-tie antenna with two folded elements (*h*=5mm) at 600 MHz.

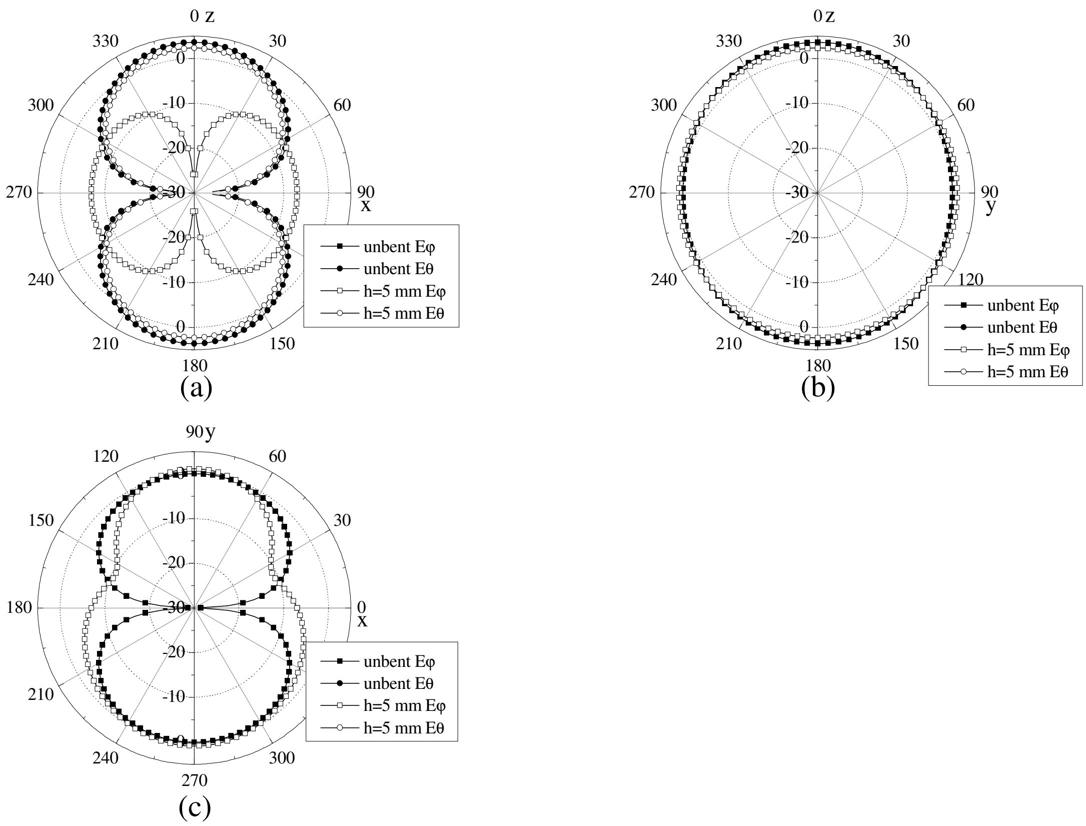


Fig. 6 Simulated radiation patterns of unbent bow-tie antenna and bent bow-tie antenna with two folded elements in (a) zx-plane , (b) zy-plane, and (c) xy-plane at 600 MHz.

References

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