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3 BEAM SWITCHED TOP LOADED MONOPOLE ANTENNA

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1 Introduction

Antenna pattern diversity reduces multipath fading and improves throughput of wireless local area network. A typical example of using wire antennas is four monopole antennas with corner reflectors. However, wire antenna is difficult to have antenna built in terminal. On considering built in antenna for terminal, planar antenna is desired. The patch Yagi-Uda array antenna consist of a driven patch and parasitic patches [1]. With sharing reflector patches, antenna pattern can be changed for four directions [2]. To downsize this antenna and improve properties of the front-to-back (F/B) ratio, parasitic director patches are shared by two opposite sector arrays and central hexagon shaped director patch is shared by all six sectors [3]. However, these antennas need many elements, and these antenna size needs more downsizing with considering built in antenna.

In this paper, 3 beam switched top loaded monopole antenna is proposed. This antenna has three top loaded monopole antenna and central hexagon shaped patch. Central hexagon shaped patch becomes reflector, and three top loaded monopole antenna is placed around hexagon patch with 120 degrees interval. With feeding one top loaded monopole antenna and setting other ports to 50 Ω, this radiation pattern tilts toward fed top loaded monopole antenna. This antenna enable to reduce the number of elements and to downsize antenna size.

2 Terminal Condition of Radiation Element

Figure 1 shows the construction of a proposed antenna. Top loaded monopole antennas are arranged around a hexagon patch with 120 degrees interval. When one radiation element (port 1) is excited, three terminal conditions of other element (port 2, 3) are examined, as shown in the following: (*a*) 50 Ω termination, (*b*) open, and (*c*) short.

The diameter of feed and short pins is 1.0 mm, and this antenna is printed on a dielectric substrate of ε_r=2.6, thickness of 1.6mm. CST Microwave Studio is used for the electromagnetic analysis. Figure 2 shows return loss characteristics, and this antenna has two resonant frequencies. Figures 3–6 show radiation pattern characteristics in xy and zx plane at f1 (lower frequency) and f2 (higher frequency). Though the F/B ratio of conditions (*b*), (*c*) is about 10 dB at f2, the condition (*a*) becomes 20.1 dB, and suitable for the beam switched antenna.

Figures 7 and 8 show current distributions of the condition (*a*) at f1 and f2. The current distribution of the patch of port 1 becomes out of phase in the patch of port 2, 3, and a current is strongly distributed in the central hexagon patch at f1. Therefore, a maximum radiation direction almost becomes broadside. Moreover, the current of the patch of port 1 becomes in phase at the patch of port 2, 3, and a current is hardly distributed in the central hexagon patch at f2. The current distribution in the patch of port 1 is stronger than port 2, 3. The top loaded monopole array of 3 element tilt the pattern to the patch of port1 that current is strongly distributed in the high frequency. When one element is excited and other element is terminated

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in each condition, the pattern is tilted to the radiation element in the high F/B ratio. The beam can be changed in 3 direction by choosing radiation element.

3 Examination of Structure Parameters

The F/B ratio and the horizontal half beam width are examined to use as the beam switched antenna. The terminal condition (a) is chosen. The parameters to examine are ps (size of ground plane), hs (length of central hexagon patches), d (interval of center and radiation elements), and rd (interval of radiation port and short pin). Figures 9–12 show the F/B ratio and the horizontal hald beam width, when ps, hs, d, and rd are varied. When the size of the ground plane becomes small, a F/B ratio is improved. Parameters d and rd affect the matching condition and a F/B ratio. The frequency bandwidth in $d = 1.1$ and $rd = 2.5$ [mm] becomes wide in comparison with $d = 0.8$ and $rd = 2.0$ [mm]. A high F/B ratio is realized by choosing the parameters: $d = 1.1$, $rd = 2.0$, $d = 0.8$, and $rd = 2.5$ [mm]. Table 1 shows the optimized results of the antenna performance. Three terminal conditions of the element except for the feed port are also discussed at the antenna structure of the parameter as shown in Tab. 1. The radiation efficiency in each condition is over 97 %. The total efficiency of the condition (a), (b), and (c) are 64.6, 93.0, and 73.8 %. However, a gain in the maximum radiation direction changes within 1 dB in each condition. This antenna can improve the F/B ratio by the suppression of the radiation to the terminal port.

4 Conclusion

In this paper, 3 beam switched top loaded monopole antenna was proposed. A F/B ratio was improved by terminating the radiation element with 50 Ω. A high F/B ratio could be realized by optimizing the interval of the center element and the radiation element and the interval of port of the radiation element and short pin. A F/B ratio was realized a maximum of 22.7 dB, and the pattern could be changed in 3 direction by choosing an excitation element.

References

[1] J. Huang and A. C. Densmore, "Microstrip Yagi array antenna for mobile satellite vehicle application, "*IEEE Trans. Antennas Propagat.*, vol. 39, no. 7, pp. 1024-1030, July 1991.

[2] D. Gray, J. W. Lu and D. V. Thiel, "Electronically steerable Yagi-Uda microstrip patch antenna array, "*IEEE Trans. Antennas Propagat.*, vol. 46, no. 5, pp. 605-608, May 1998.

[3] N. Honma, F. Kira, T. Maruyama, K. Cho and H. Mizuno, "Compact six-sector antenna employing patch Yagi-Uda array with common director, "2002 *IEEE AP-S Digest*, vol. 1, pp. 26-29, June 2002.

Table 1: Optimized result

Front to back ratio	22.7 dB
Horizontal power beam width	232.1 deg.
Maximum Directivity	6.1 dBi @ 33 deg.
Frequency	5.2 GHz
Return Loss	−16.53 dB
−10 dB Bandwidth	130 MHz

ps=48.0, hs=9.0, d=0.8, rd=2.5, rs=10.8 [mm]

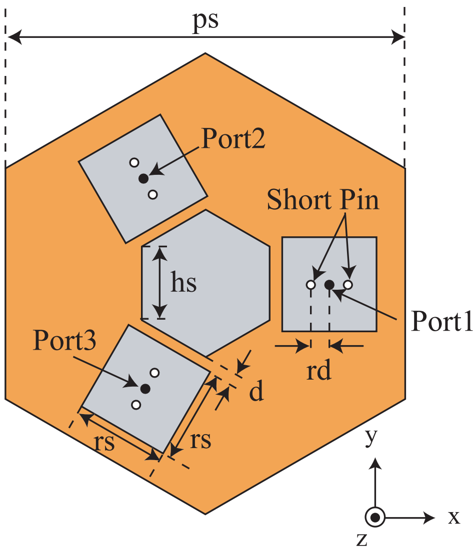
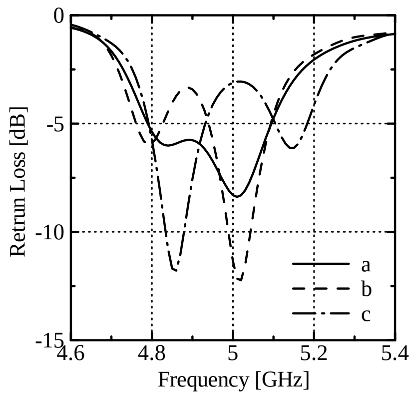


Figure 1: Analytic model



ps=60.0, hs=9.0, d=1.0, rd=2.0, rs=10.8 [mm]

Figure 2: Return loss characteristics of various terminations

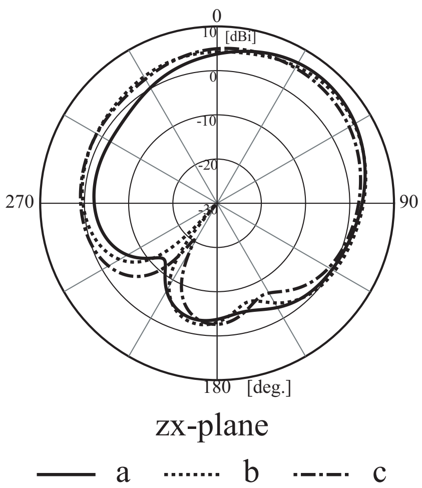


Figure 3: Radiation pattern of zx plane at f1

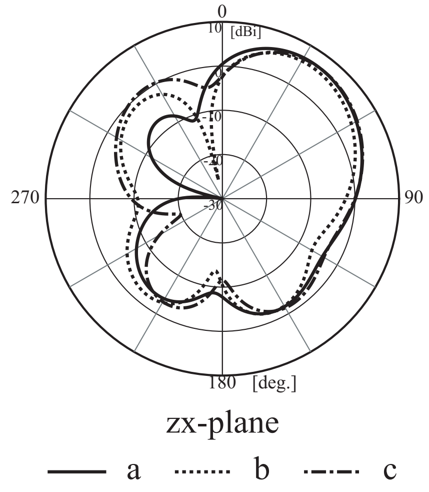


Figure 4: Radiation pattern of zx plane at f2

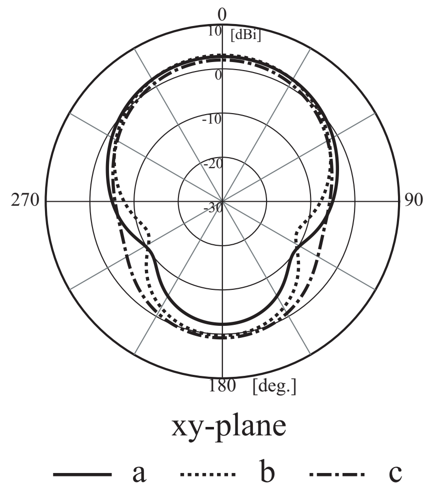


Figure 5: Radiation pattern of xy plane at f1

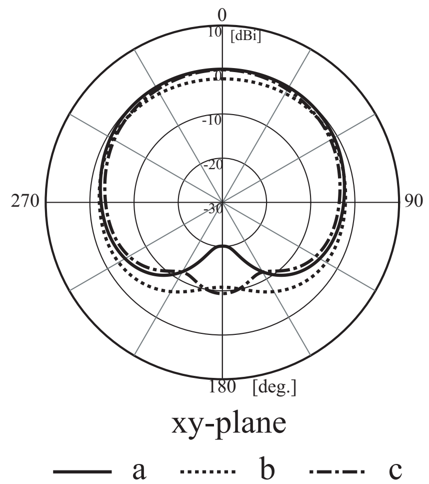


Figure 6: Radiation pattern of xy plane at f2

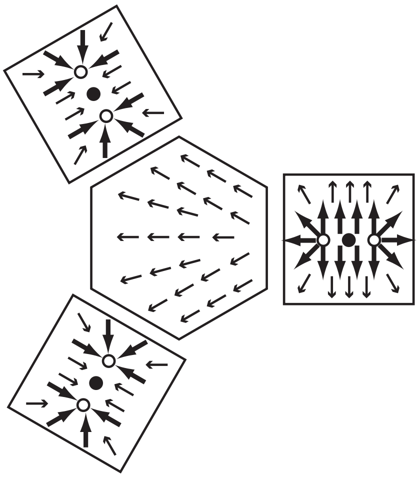
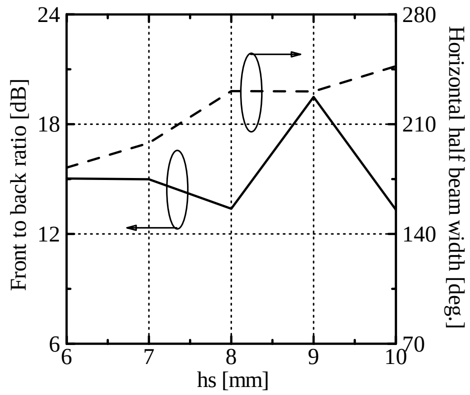


Figure 7: Current distribution at 4.84 GHz



ps=48.0, d=0.9, rd=2.0, rs=10.8 [mm]

Figure 10: F/B ratio and horizontal half beam width (hs is varied.)

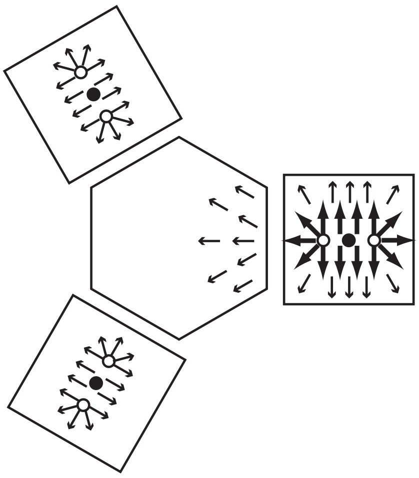
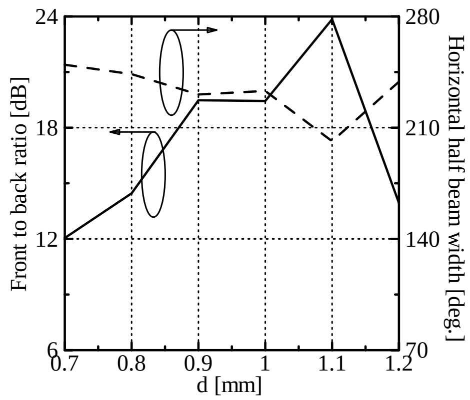
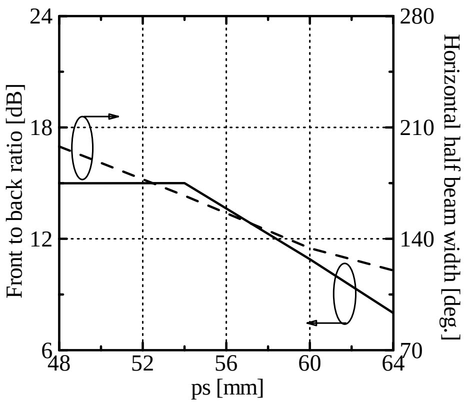


Figure 8: Current distribution at 5.01 GHz



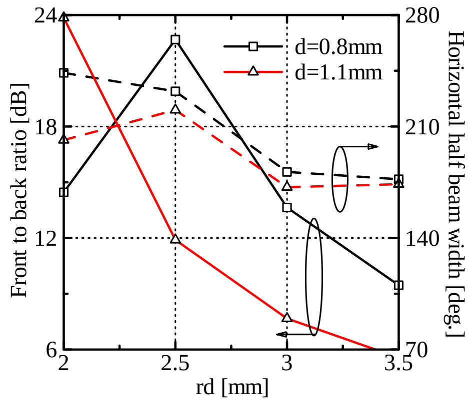
ps=48.0, hs=9.0, rd=2.0, rs=10.8 [mm]

Figure 11: F/B ratio and horizontal half beam width (d is varied.)



hs=7.0, d=0.9, rd=2.0, rs=10.8 [mm]

Figure 9: F/B ratio and horizontal half beam width (ps is varied.)



ps=48.0, hs=9.0, rs=10.8 [mm]

Figure 12: F/B ratio and horizontal half beam width (rd is varied.)