A PLANAR-TYPE FIVE-SECTOR ANTENNA WITH PRINTED SLOT ARRAY FOR MILLIMETER-WAVE AND MICROWAVE WIRELESS LANs

Manabu YAMAMOTO*, Kousuke ISHIZAKI*, Mitsuru MURAMOTO**,
Kanemi SASAKI** and Kiyohiko ITOH*

* Graduate School of Engineering
Hokkaido University
N13, W8, Kita-ku, Sapporo 060-8628 Japan
E-mail: yamamoto@ice.eng.hokudai.ac.jp

** Kokusai Electric Co. LTD
1007-176, Izumisawa, Chitose-shi,
066-8566 JAPAN
E-mail: mmuramoto@nts.kokusaidenki.co.jp

1. INTRODUCTION

High speed and high capacity Wireless Local Area Networks (WLANs), which are operated at millimeter-wave and microwave bands, are being developed in recent years. The degradation of transmission quality caused by the multipath propagation is a serious problem in such wireless networks. The use of a multi-sector antenna is the simplest way for reducing the multipath interference, and can achieve higher data transmission rates [1].

The multi-sector antenna consists of antenna elements with shaped-beams pointing at different direction. So far, various kinds of multi-sector antennas have been proposed and developed [2], [3]. However, these antennas have complex structure, and are not low profile. To satisfy the low cost and low profile requirements, it is preferable to develop a planar-type multi-sector antenna in which an antenna element with simple geometry is adopted.

This paper presents a novel planar-type five-sector antenna, which is useful for WLANs operated at millimeter-wave and microwave bands. A printed slot array with microstripline feed is adopted as the antenna element. The backward excitation is introduced to the slot array to obtain a shaped-beam suitable for WLANs. To realize the five-sector antenna using the slot array, a novel arrangement of the antenna element is proposed and considered. Measurement of a prototype five-sector antenna is carried out at 19GHz band to demonstrate the proposal.

2. PRINTED SLOT ARRAY WITH BACKWARD EXCITATION

As the basic element of the sector antenna, this paper suggests the use of a printed slot array whose geometry is depicted in Fig. 1. Rectangular slots of length l_{sn} and width w_s are cut on the ground plane of the dielectric substrate with thickness d and relative permittivity ε_r. The slots are offset in $-y$ direction with length o_{sn}, and are arranged along the microstripline of width w_f. The end of the feedline acts as a tuning stub of length l_f, and each slot is equally spaced l. To avoid unwanted back radiation, a thin cavity is attached to the ground plane. The length, width and depth of the cavity are denoted as l_c, w_c and d_c, respectively.

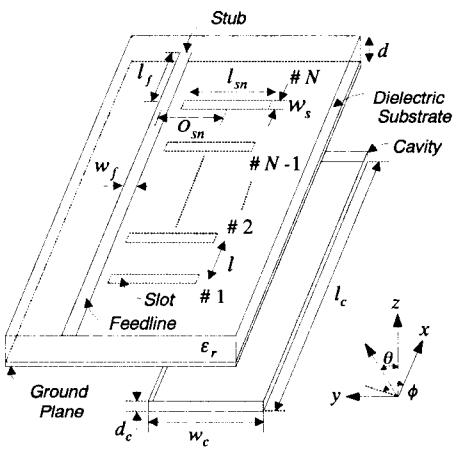


Fig. 1: Printed slot array.

A PLANAR-TYPE FIVE-SECTOR ANTENNA WITH PRINTED SLOT ARRAY FOR MILLIMETER-WAVE AND MICROWAVE WIRELESS LANs

Manabu YAMAMOTO*, Kousuke ISHIZAKI*, Mitsuru MURAMOTO**,
Kanemi SASAKI** and Kiyohiko ITOH*

* Graduate School of Engineering
Hokkaido University
N13, W8, Kita-ku, Sapporo 060-8628 Japan
E-mail: yamamoto@ice.eng.hokudai.ac.jp

** Kokusai Electric Co. LTD
1007-176, Izumisawa, Chitose-shi,
066-8566 JAPAN
E-mail: mmuramoto@nts.kokusaidenki.co.jp

1. INTRODUCTION

High speed and high capacity Wireless Local Area Networks (WLANs), which are operated at millimeter-wave and microwave bands, are being developed in recent years. The degradation of transmission quality caused by the multipath propagation is a serious problem in such wireless networks. The use of a multi-sector antenna is the simplest way for reducing the multipath interference, and can achieve higher data transmission rates [1].

The multi-sector antenna consists of antenna elements with shaped-beams pointing at different direction. So far, various kinds of multi-sector antennas have been proposed and developed [2], [3]. However, these antennas have complex structure, and are not low profile. To satisfy the low cost and low profile requirements, it is preferable to develop a planar-type multi-sector antenna in which an antenna element with simple geometry is adopted.

This paper presents a novel planar-type five-sector antenna, which is useful for WLANs operated at millimeter-wave and microwave bands. A printed slot array with microstripline feed is adopted as the antenna element. The backward excitation is introduced to the slot array to obtain a shaped-beam suitable for WLANs. To realize the five-sector antenna using the slot array, a novel arrangement of the antenna element is proposed and considered. Measurement of a prototype five-sector antenna is carried out at 19GHz band to demonstrate the proposal.

2. PRINTED SLOT ARRAY WITH BACKWARD EXCITATION

As the basic element of the sector antenna, this paper suggests the use of a printed slot array whose geometry is depicted in Fig. 1. Rectangular slots of length l_{sn} and width w_s are cut on the ground plane of the dielectric substrate with thickness d and relative permittivity ε_r. The slots are offset in $-y$ direction with length o_{sn}, and are arranged along the microstripline of width w_f. The end of the feedline acts as a tuning stub of length l_f, and each slot is equally spaced l. To avoid unwanted back radiation, a thin cavity is attached to the ground plane. The length, width and depth of the cavity are denoted as l_c, w_c and d_c, respectively.

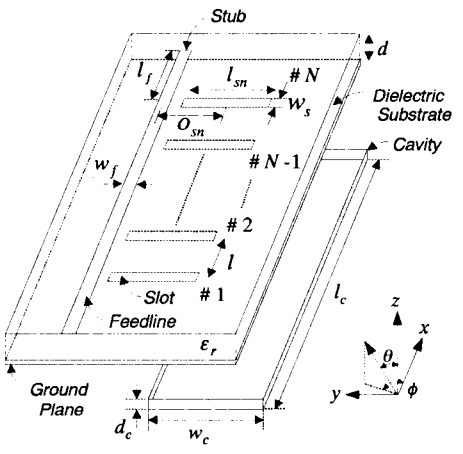
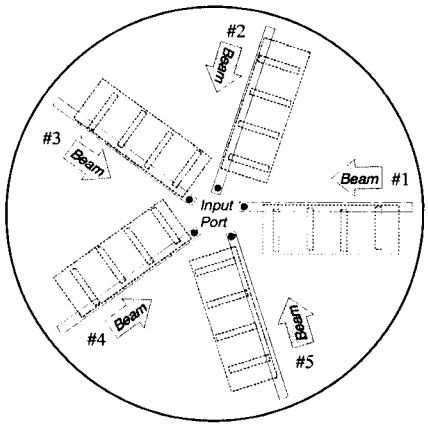
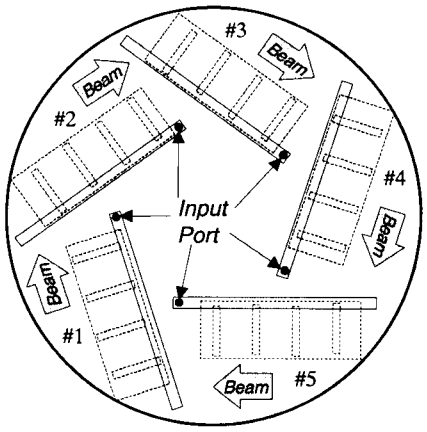


Fig. 1: Printed slot array.

measurements, and the broken lines indicate the calculations. The calculated results agree well with measurement and therefore the validity of the design with calculation is confirmed. The return loss of about – 15 dB is obtained at 19.5GHz. From Fig. 4(a) it is observed that the inclination of the main beam away from the broadside is achieved. Fig. 4(b) is the pattern as a function of ϕ evaluated maintaining θ at a specific angle (here θ is fixed at -60°). The half power beam width for this pattern is about -80°, which is suitable for a five-sector antenna. The calculated and measured results of maximum gain are 9.5dBi and 9.8dBi, respectively.



(a) Conventional type



(b) A novel type

Fig. 5: Arrangement of the element.

3. PLANAR-TYPE FIVE-SECTOR ANTENNA

When the multi-sector antenna is designed with various kinds of antenna elements, the arrangement of the element becomes an important issue. It is important to develop the arrangement that can reduce the mutual coupling between the antenna elements, since the coupling leads to unwanted results, such as degradation of the shaped beam.

The most popular way for constructing the multi-sector antenna is to arrange the antenna elements radially as depicted in Fig. 5(a) [1], [3]. For the slot array with backward excitation, however, it is not preferable from the mutual coupling viewpoint. This is because the main beam of the excited sector points to opposite side of sectors that are not excited. Thus this paper suggests a novel arrangement of the element as shown in Fig. 5(b) to build the planar-type multi-sector antenna using the slot array.

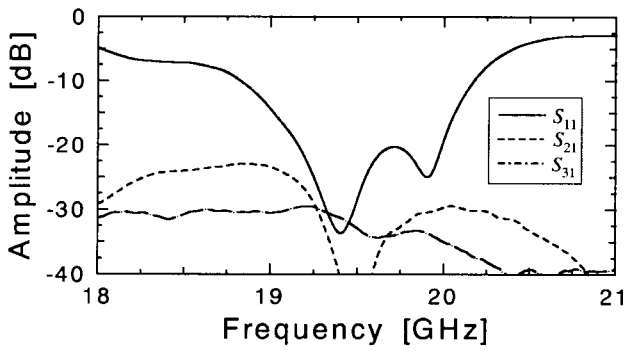
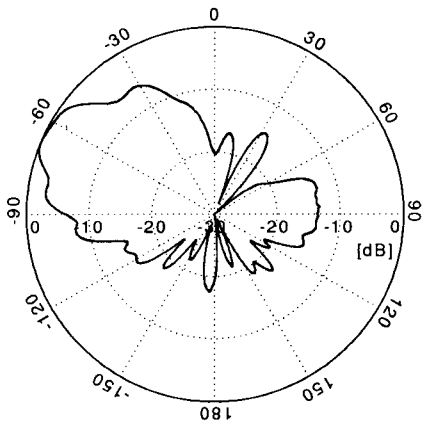


Fig. 6: Measured frequency dependence of reflection and transmission coefficients.

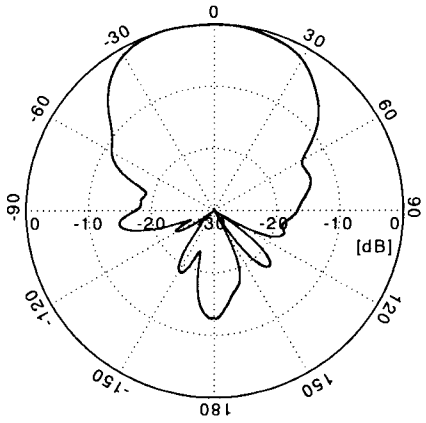
A prototype five-sector antenna, where the arrangement of Fig. 5(b) is employed, was fabricated on a substrate with diameter of 62mm. Fig. 6 shows measured reflection and transmission coefficients. Note that ports 1, 2 and 3 correspond to 1st, 2nd and 3rd sector, respectively. The reflection coefficient $|S_{11}|$ takes a minimum near the design frequency of 19.5GHz. The transmission

coefficients $|S_{21}|$ and $|S_{31}|$, which correspond to the mutual coupling between the sectors, are suppressed less than -30 dB at the above frequency. Thus it is confirmed that the proposed arrangement of the element is effective in reducing the mutual coupling between the sectors.

Fig. 7 shows the measured radiation pattern of the prototype sector antenna. Note that 1st sector was selected in the measurement. The inclination angle of $\theta \approx -60^\circ$ is observed from the radiation pattern of Fig. 7(a). This value agrees well with the results of the single array treated in the previous chapter. The half-power beam width for the pattern of Fig. 7(b) is -71°, which is slightly narrower than that of the single array. However, this angle is appropriate for covering the entire azimuth plane with five sectors.



(a) xz-plane



(b) Conical plane

Fig. 7: Measured radiation pattern.

4. CONCLUSIONS

In this paper a novel planar-type five-sector antenna, which is suitable for millimeter-wave and microwave WLANs, has been proposed and developed. As the antenna element of the sector antenna, a printed slot array with backward excitation has been employed and designed. To realize the five-sector antenna using the slot array, a novel arrangement of the antenna element has been proposed and considered. A prototype sector antenna, in which the proposed arrangement is adopted, has been fabricated and measured at 19GHz band. Measured results have confirmed the effective performance of the proposed sector antenna.

ACKNOWREDGEMENT

This research is supported by Grant-in-Aid for Scientific Research (A)(2)11355017 from the Ministry of Education, Science, Sports and Culture of Japan.

REFERENCES

[1] G. Passiopoulos *et al.*, *Proc. of ICAP'97*, 1, pp.394-398, Apr. 1997.

[2] Y. Murakami *et al.*, *IEEE AP-S Symp. Digest*, 4, pp.2248-2251, Jun. 1998.

[3] T. Maruyama *et al.*, *Proc. of ISAP'96*, 4, pp.1017-1020, Sep. 1996.

[4] Collin and Zucker, *Antenna Theory*, Part I, Chap.14, McGraw-Hill, 1969.

[5] D. M. Pozar, *IEEE Trans. Antennas Propagat.*, AP-34, 12, pp.1439-1446, Dec. 1986.