Switched Beam Antenna Using Parasitic Elements

#Kenta ABE [1], Hiroyuki ARAI [1], Nobuyasu TAKEMURA[2], Tsutomu MITSUI[2]
[1] Department of Electrical and Computer Engineering, Yokohama National University
79-5, Tokiwadai, Hodogaya-ku, Yokohama-shi, 240-8501, Japan
#E-mail: d10gd101@ynu.ac.jp
[2] SAMSUNG Yokohama Research Institute
2-7, Sugasawa-cho, Tsurumi-ku, Yokohama-shi, 230-0027, Japan

Abstract

This paper presents a dual polarized switched beam antenna. To achieve switched beam, 4-wire elements arranged near the square patch antenna are operated as a reflector. The beam is tilted by the on/off state of switch for wire elements. The proposed antenna can switch 3-beams by switching the wire element as a reflector along TE_{01} or TE_{10} current mode on the patch antenna. This antenna can also switch polarization by selecting the feeding port of patch antenna.

Keywords: Beam tilt Dual-polarization Parasitic element Patch antenna Switched beam antenna

1. Introduction

With the developments in wireless communication, indoor base-station setting is increased. Indoor wireless communication systems are often subject to fluctuations due to multi-path propagation by reflecting the wall or obstacle. In this environment, there are often the coherence fading which deteriorates the channel capacity. The switched beam from the base-station can easily improve the channel capacity of the wireless communication systems. One method for switching beams is to use parasitic elements. They are arranged around the excited element, and the switched beam is achieved by switching the parasitic elements [1]-[5]. The features of these antennas are that arranged wire elements are same shape with the excited element. For example, when the monopole antenna is used as the excited element, parasitic elements adopt wire elements like monopole antenna [1]-[3]. Also, when the patch antenna is used as the excited element, parasitic elements adopt planar elements like patch antenna [4]-[5]. However, the switched beam antenna which combines wire and planar elements is not reported.

This paper proposes the switched beam antenna which is a combination of a patch antenna as the excited element and wire elements as parasitic elements. Wire elements are placed along TE_{01} or TE_{10} current mode on the patch antenna. The proposed antenna can switch 3-beams and dual-polarization by switching the state of switches with wire elements and feeding ports. The features of this antenna are low-profile and small by placing wire elements around excited element. In section 2, the proposed antenna geometry and operation are explained. The section 3 shows the simulation and measurement results and it concludes in section 4.

2. Antenna Geometry and Mechanism

This section presents switched beam antenna using wire elements arranged around the square patch antenna as shown in Fig. 1. The square patch antenna has two orthogonal ports for dual polarization, and 4-wire elements are arranged around the patch antenna. One wire element consists of 2-L-shaped wire elements and 2-conductor pads. The wire element punctures a hole through the substrate, and is connected with the conductor pad on the bottom of the substrate. The switch which can change the state of wire elements is set up between pads. If the switch is on, conductor pads are connected i.e. the total length of wire element is the same length as a reflector. On the other hand, if the switch is off, conductor pads are not connected i.e. the wire element do not operate as a reflector. Then the radiation pattern of the proposed antenna is switched by the state of switches setting between conductor pads. Only one pad is connected with the antenna ground by a thin line which is the bias line for the PIN diode switch. In this paper, PIN diodes are not mounted for the switch. In the simulation, the switch consists of the connection with conductor or not.

Next, we explain about beam switching mechanism. Each one of 4-wire elements has the on/off switch. All wire elements operate as a reflector i.e. a beam of patch antenna tilts in the opposite direction to the part of the on switch. For example, for Port 1 excitation in Fig. 1, when the switch of wire element #2 is off and of wire element #4 is on, beam tilts to the positive y-axis. On the other hand, when the switch of wire element #2 is on and of wire element #4 is off, beam tilts to the negative y-axis. If we do not need tilt beam, wire element #2 and #4 should be on because S_{11} characteristic of the proposed antenna is deteriorated when both wire elements are off. Using the above 3-way switching (#2-#4; off-on, on-off, and on-on), this antenna can switch 3-beams for Port 1 excitation, and also for Port 2 excitation.

3. Simulation and Measurement

This section presents the simulation and measurement results of proposed antenna. The target frequency band is 2.6 GHz band. The fabricated antenna is shown in Fig. 2. This substrate is FR-4 (relative permittivity of 4.8). The 3-beams switching pattern comparing simulation and measurement is shown in Fig. 3. This pattern is normalized by the maximum gain of the state of off-off in the simulation and measurement. In the state of off-on, we confirm that it is effective in beam tilt and the switching. Especially, the direction of maximum gain and null in the measurement are agreed with the simulation. The back-lobe of radiation pattern is a litte bit high due to small ground size of the patch antenna which is 33 square millimeter ($0.3\ ə_0 \times 0.3\ ə_0$). The ground size must be small to make space for the switch of wire elements. However, the back-lobe reflects on front when the proposed antenna is installed on the wall. We confirm that the distance more than 30 mm from the antenna bottom has no impact on the beam switching in the simulation. In the state of on-off, it is also effective in this switching due to symmetry of the antenna model. In the measurement, with or without copper tape achieves the switching of the switch part by connecting between conductor pads.

Next, the dual-polarization pattern is shown in Fig. 4. When Port 1 is excited, the main polarization is $E_{ű}$ (ű = 0°). Also, when Port 2 is excited, the main polarization is $E_{ű}$ (ű = 90°) because the radiator is the square patch and two ports are orthogonal. To switch excited ports changes TE_{01} and TE_{10} current mode on the patch, i.e. archives dual-polarization. 3-beams switching can be achieved by switching the corresponding wire elements. Briefly, for Port 1 excitation, the beam switching is operated by the wire elements #2 and #4, and also for Port 2 excitation, it is operated by the wire elements #1 and #3. By these switching ways, we verify that the proposed antenna can switch 3-beams and dual-polarization by the experiment. In addition, S_{11} characteristic of this antenna is shown in Fig. 5. It has more than 40 MHz frequency band in both the simulation and measurement.

4. Conclusion

We proposed the switched beam antenna to switch 3-beams and dual-polarization which is horizontal and vertical plane by switching the state of switches with wire elements. This antenna consisted of one square patch antenna and 4-wire elements placed around the patch antenna. We obtained beam switching by the wire switch and feeding ports. In addition, the beam switched antenna pattern is verified by the experiment. The future challenges are to improve bandwidth to wideband and set up the PIN diodes between pads on the bottom of substrate for the on/off switch.

References

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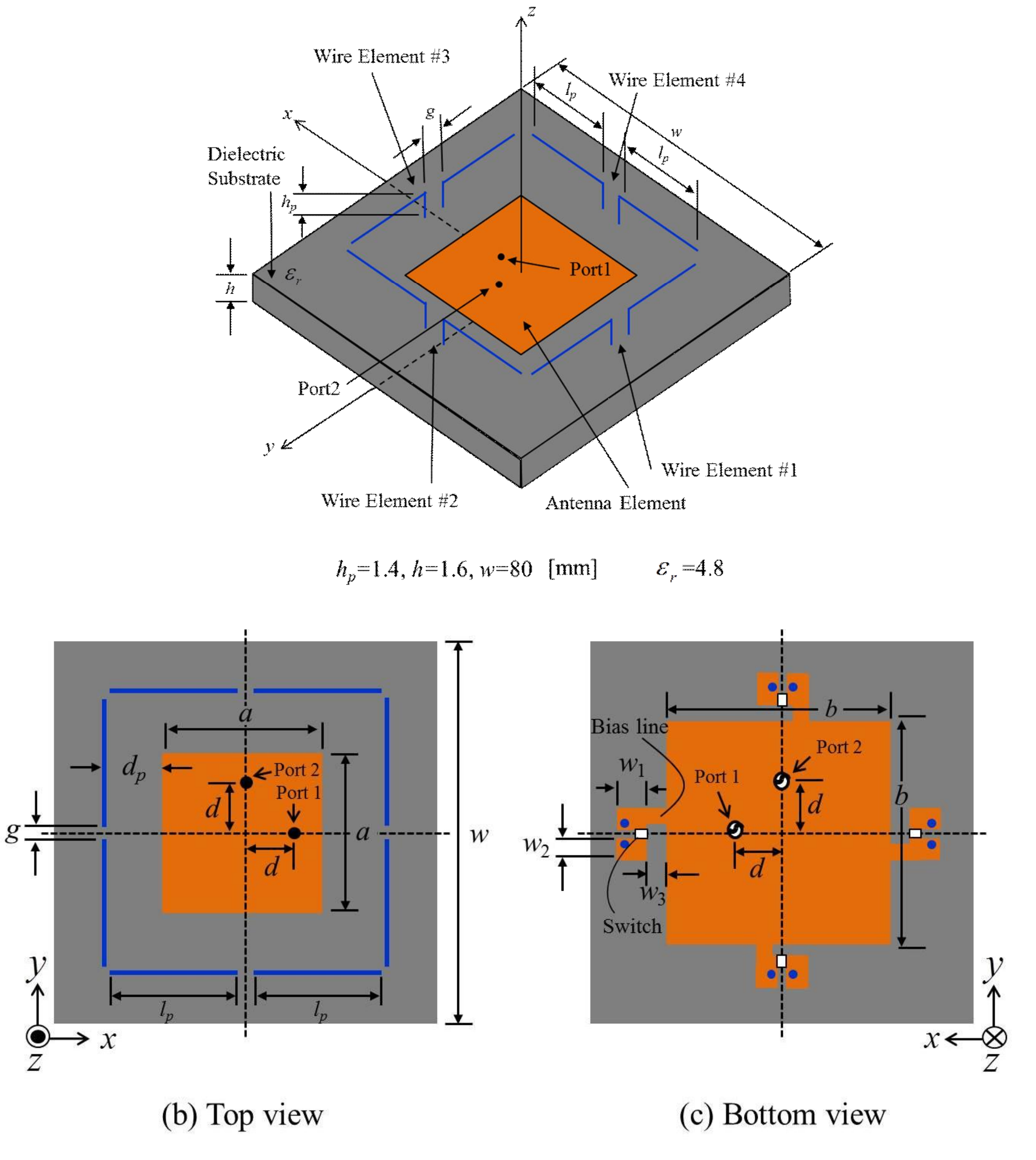
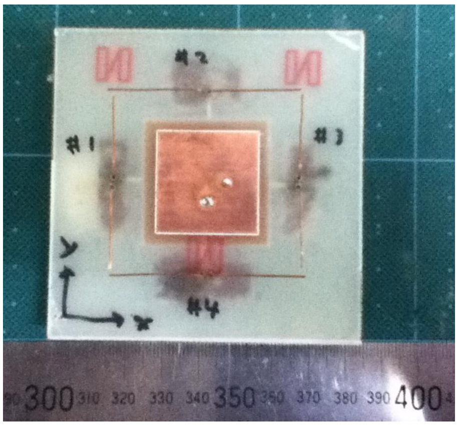


Figure 1: Proposed antenna geometry



Firure 2: Fabricated antenna

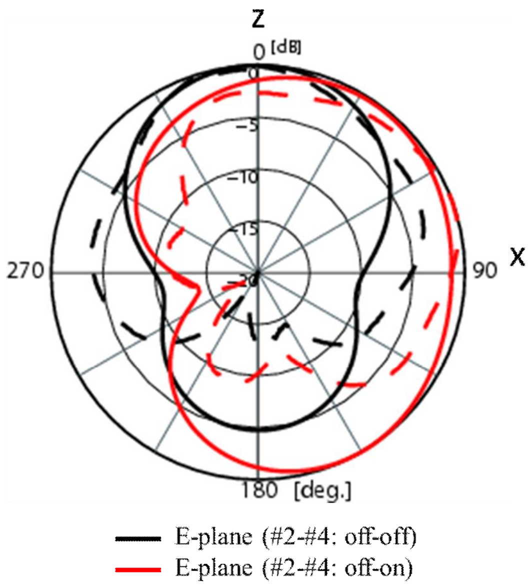


Figure 3: 3-beams switching pattern
Solid line is simulation at 2.67 GHz.
Dot line is measurement at 2.67 GHz.

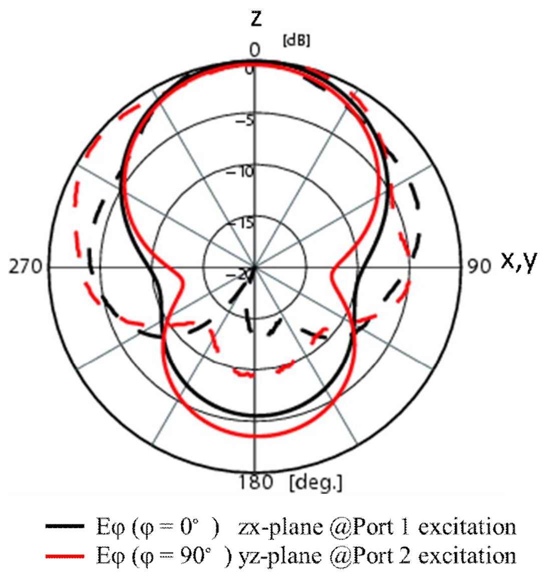


Figure 4: Dual-polarization pattern
Solid line is simulation at 2.67 GHz.
Dot line is measurement at 2.67 GHz.

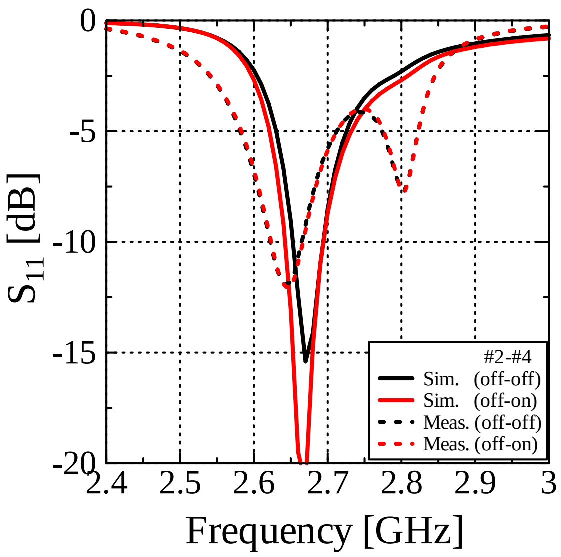


Figure 5: S_{11} characteristic