A Wideband Reconfigurable Feeding Network for Quadruple Polarization Antenna

Ghoo Kim, Kwang-Seok Kim, Soo-Chang Chae, Hyun-Young Cho, and Jong-Won Yu
School of Electrical Engineering
Korea Advanced Institute of Science and Technology (KAIST)
291 Daehak-ro, Yuseong-gu, Daejeon, 34141, Republic of Korea

Abstract - A Wideband reconfigurable feeding network for quadruple linear and circular polarization is proposed in this paper. The proposed reconfigurable feeding network is designed with RF switches and wideband coupler. The feeding network provides selective linearly and circularly polarized states. RF switches and double-section branch-line coupler operates in a wideband frequency range. A stacked patch antenna is introduced as a radiator to generate quadruple polarization in a wideband frequency. Peak gain is above 4.8dBi for the respective polarization in the 2.2GHz to 2.6GHz range. The feeding network itself covers over 1GHz (2.0GHz-3.0GHz).

Index Terms — Quadruple polarization, reconfigurable polarization, RF switch, reconfigurable feeding network

1. Introduction

Antenna polarization influences on the performance of wireless communication system. In particular, polarization mismatch loss degrades receiving power and cross-polarized receiving antenna is fatal to performance of communication. Therefore, an antenna which provides multiple polarization is one of the solutions to relief the polarization mismatch loss.

Accordingly, quadruple polarization antenna has been proposed. Typically, antenna or feeding network provides selective states to generate quadruple polarization. PIN diode [1]-[2] and RF Switch [3]-[4] are introduced to realize the quadruple polarization antenna.

In this paper, RF switches and double-section branch-line coupler is presented for the wideband reconfigurable feeding network of quadruple polarization antenna. Also, a stacked patch antenna is introduced as a radiator to demonstrate the valid performance of quadruple polarization in the wideband frequency range. The targeting center frequency is ISM band of 2.45GHz for the convenient design process.

2. Design of the Proposed Quadruple Polarization Reconfigurable Feeding Network and Antenna

(1) Wideband Reconfigurable Feeding Network

The proposed wideband reconfigurable feeding structure shown in Fig. 1 is designed with one SP4T, two SPDT, and double-section branch-line coupler. According to the states of RF switches, the proposed reconfigurable feeding network respectively operates as a single-port linear-polarization modes (H-LP, V-LP) and two-port circular-polarization modes of 90-degree phase difference (RHCP, LHCP).

Fig. 1. The proposed reconfigurable feeding network and the configuration of port for quadruple polarization

<table>
<thead>
<tr>
<th>Polarization</th>
<th>Port A</th>
<th>Port B</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-LP</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>LHCP</td>
<td>$\sqrt{2}/2\angle 90^\circ$</td>
<td>$\sqrt{2}/2\angle 0^\circ$</td>
</tr>
<tr>
<td>RHCP</td>
<td>$\sqrt{2}/2\angle 0^\circ$</td>
<td>$\sqrt{2}/2\angle 90^\circ$</td>
</tr>
<tr>
<td>V-LP</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Also, the RF switch usually operates in the wideband frequency range. Likewise, the frequency range of hybrid coupler should be as wide as possible to utilize the frequency of RF switch in the feeding network. Thus, double-section branch-line coupler shown in Fig. 2 is designed.

Fig. 2. Double-section branch-line coupler
Fig. 3. Parameter of the fabricated stacked patch antenna

(2) Design of the Stacked Patch Antenna

Antenna should be able to cover the wideband frequency range to demonstrate the characteristics of the proposed wideband reconfigurable feeding network. As an applicable antenna, the stacked patch antenna is designed.

Each square patch of stacked patch antenna was fabricated on FR-4 substrate of 0.8mm height. Patch size and distance between substrates are shown in Fig. 3. The position of probe feed is 24mm apart from the center of the driving patch. Also ground size is 120mm x 120mm.

3. Result and Discussion

Fig. 4 shows fabricated quadruple polarization wideband reconfigurable stacked patch antenna. SKY13431-374LF of Skyworks Solutions and QPC6044 of Qorvo are adopted for SPDT and SP4T RF switch, respectively. Even though RF switches operate from 0.5GHz to 6.0GHz, relatively narrow bandwidth of coupler and antenna limits the operation frequency range. Thus, the bandwidth of wideband coupler and stacked patch antenna should be solely measured.

Fig. 5 shows the characteristics of double-section branch-line coupler. Return loss is higher than 10dB over 2-3GHz range. Amplitude and phase imbalance is under 1dB, 5-degree from 2.0GHz to 2.675GHz range, respectively. Also, return loss of the stacked patch antenna is shown in Fig. 6. Measured impedance bandwidth ranges from 2.15GHz to 2.57GHz and port isolation is higher than 15dB within the impedance bandwidth.

Thus, reconfigurable feeding network itself covers 1GHz range (over 40%) with the introduction of the double-section branch-line coupler. In other words, stacked patch antenna can generate quadruple polarization in the entire bandwidth (420MHz; 17.14%) with the help of the proposed wideband reconfigurable feeding network.

The result of gain measurement for each polarization is shown in Fig. 7. Measured gain is compared to the simulated overall gain of antenna with reconfigurable feeding network. Each peak gain of V-LP, H-LP, RHCP, and LHCP results in 5.59dBi, 5.96dBi, 5.75dBi, and 5.25dBi respectively. Also, quadruple polarization covers from 2.2GHz to 2.6GHz above 4.8dBi gain, and drops drastically over 2.6GHz.

4. Conclusion

A wideband reconfigurable feeding network for quadruple polarization is proposed in this paper. The design process is presented in this paper. Also, the generation of quadruple polarization is demonstrated with the stacked patch antenna. According to the measurement, peak gain is over 4.8dBi for each polarization in the range from 2.2GHz to 2.6GHz.

References


