Traveling-wave Design of Cross-junction Power-dividers for Two-dimensional Microstrip Planar Array with 45-degree Polarization in Submillimeter-wave Band

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***Abstract* - In the design of two-dimensional microstrip antennas, comparing with the end feeding, the center feeding has advantages of wide frequency bandwidth due to decreasing long line effect and low loss due to the shorter length of the feeding line. However, the area of center feeding circuit forms no radiation area around the center, which causes growing sidelobes. A two-microstrip-output waveguide-transition is developed to realize two-dimensional planar array composed of only one piece of substrate. To reduce no radiation area at the center, eight steps of cross-junction with a two-way power divider at the termination are designed by travelling-wave operation. The simulated performance of the designed two-dimensional microstrip planar array with 45-degree polarization in submillimeter-wave band is evaluated in this paper.**

***Index Terms* — Submillimeter wave, Microstrip antenna, Array antenna, Planar array, Feeding circuit, Power divider.**

1. Introduction

Submillimeter-wave technologies have been developed for short-range automotive-radars [1], fixed wireless accesses [2], base station links, and so on. High gain and low cost planar antennas are expected for these applications. Microstrip antennas are promising candidate for use in submillimeter-wave band. The possible gain is limited for microstrip antennas due to its conductor, radiation and dielectric losses. However, microstrip antennas can be manufactured by print technologies, therefore, low cost and high degree of design freedom are expected [3].

We have developed center feeding two-dimensional microstrip planar arrays for high gain and broad bandwidth. To reduce the size of no radiation area around the center of the antenna on the feeding circuit, we designed a compact feeding circuit composed of eight cross-junctions and a terminated two-way power divider in this work. Microstrip comb-line antennas are designed independently and are connected to all ports. The performance of the antenna is demonstrated in this paper.

2. Microstrip Antenna Fed by Cross-junction Power-dividers

A center-feeding two-dimensional microstrip comb-line planar antenna fed by series connected cross-junctions are designed. The printed pattern on the substrate is shown in Fig. 1. To feed from the backed waveguide at the center of the antenna, a two-microstrip-line-output planar waveguide-transition is designed [4]. The RF power input into the waveguide travels to both microstrip lines. The transmitting power is divided to all ports equally by traveling-wave design. 15-element microstrip comb-line antennas [5] connected all the feeding ports radiates in Taylor distribution with sidelobe level lower than −17 dB to compensate for the sidelobe increasing due to the no radiation area. To excite all elements in phase, the feeding line of upper left and lower right quadrants are extended by one-half guide wavelength away from the junctions for phase adjustment of 180 degrees.

The cross-junctions need wide control range of dividing ratio. Equivalent circuit of the cross-junction is shown in Fig. 2. The cross-junctions consist of two impedance transformers. The impedance transformers of the second step Z'_{10}, Z'_{20} controls dividing ratio. On the other hand, the impedance transformer of the first step Z'_0 matches the combined impedance of the branch against the characteristic impedance of the port 1. However, the steps at the connections of the

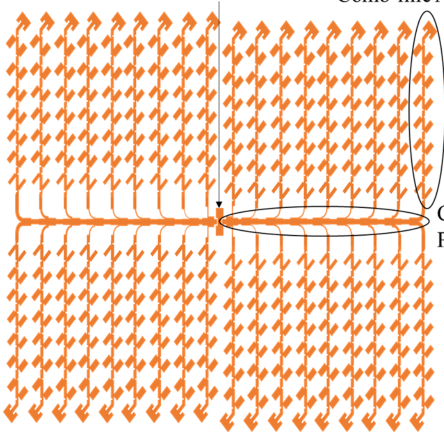

Fig. 1. Structure of the two-dimensional microstrip planar array.

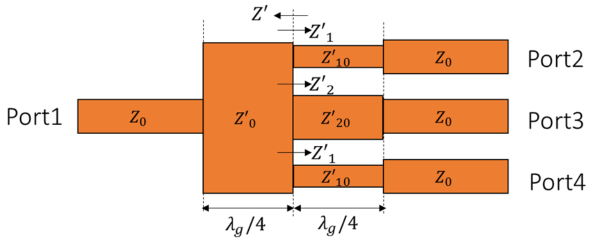

Fig. 2. Equivalent circuit of the cross-junction.

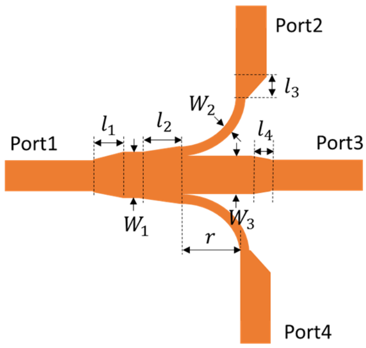

Fig. 3. Tapered structures of cross-junction.

different line widths cause degradation of the reflection characteristic and frequency bandwidth. Therefore, tapered structures are introduced at the connections of the different lines by gradually change of the impedance as shown in Fig. 3. The tapered structures are applied at the connections of all four ports at the transition.

3. Simulated Performance of the Antenna by Cross-junction Power-dividers

The feeding circuit composed of eight cross-junctions and a terminated two-way power divider is designed by traveling-wave operation. The scattering parameters of the feeding circuit is shown in Fig. 4. The bandwidth of reflection lower than –20 dB was 3.5 GHz. The deviation of the power dividing ratio to nine output ports was 1.5 dB.

The simulated radiation patterns of the two-dimensional microstrip planar array in Fig. 1 is shown in Fig. 5. The gain was 30.9 dBi. The first sidelobe level in vertical and horizontal planes to the feeding circuit was –11.7 dB and –13.8 dB, respectively. The first sidelobe level in the vertical plane of the conventional antenna fed by T-junctions was –9.3 dB. The proposed one was improved by 2.4 dB. The theoretical first sidelobe level of uniform aperture distribution is –13.26 dB which is close to the simulated sidelobe level.

4. Conclusion

Center-feeding two-dimensional microstrip planar array with 45-degree linear polarization was designed in the submillimeter-wave band for low loss and wide frequency band. The compact feeding circuit composed of eight cross-junctions and a terminated two-way power divider was designed by traveling-wave operation. Taper structures were introduced at the connections of impedance transformers for broadband matching characteristics.

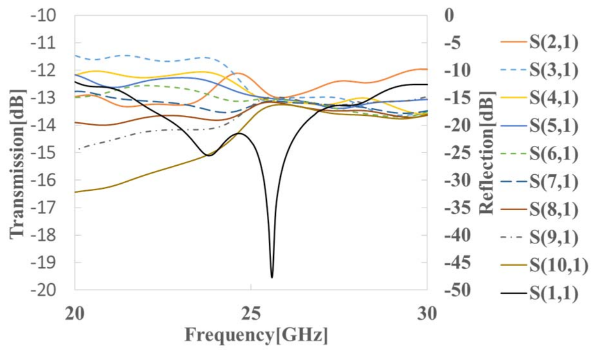

Fig. 4. Scattering parameters of the feeding circuit.

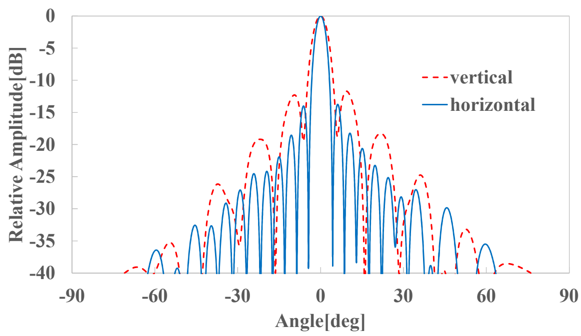

Fig. 5. Radiation patterns of the antenna.

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