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Continuous Transverse Stub (CTS) Array Antenna

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1. Introduction

Continuous Transverse Stub (CTS) planar array antenna was firstly invented in early 1990' [1]-[3]. The advantages of this type array include compact format, light weight, low loss and insensitivity to dimensional tolerances accuracy [2]. Besides, the present forms of CTS antenna have wide bandwidth, low dissipative losses compared with the conventional planar antennas. And it has been successfully used to many different applications, including electronically-scanned and dual-polarized implementations. In [4], dual-polarized and electronically-scanned applications are introduced. CTS antennas have many different forms which include coaxial, coplanar waveguide and rectangular waveguide, etc. In [6], CTS array antenna has been productized in support of 23, 26 and 38GHz point-to-point radio products.

In this paper, a planar CTS array structure having a parallel-plate waveguide feed with multi-step impedance transformation is proposed. The structure is shown in Figure 2. Impedance transformation are not only applied to feed network but also used to radiating elements. It reduces the return loss and the dimension of the entire antenna.

2. Antenna Design

CTS antennas are very different from any other forms planar array antenna in the entire antenna structure, feed and radiating cells.

2.1 The Radiating Element

CTS array antenna exploits a unique stub element as its radiator basis. The cross section for a portion of radiators of continuous transverse stub air-filled array antenna is illustrated in Figure 1. The multi-stage combination of parallel-plate waveguide designed here provided a wideband impedance matching between waveguide and free-space. The reflection coefficient of the unit over a range of operation frequencies depends on the width of stub, the element-to-element spacing and dielectric constant of filled dielectric material.

2.2 The Power Divider

Feed architecture is shown in Figure 2. This parallel-plate corporate feed network consists of E-plane tee junctions, multi-stage steps and E-plane bends. The feed network behaves as a multi-stage transformer, matching radiator and linear-source impedance over a broad range of operating frequencies. E-plane bends and tees are designed to cancel the reactive components, so that there is only pure impedance, thereby improving the operating bandwidth. Input impedance of an array of radiating elements depends strongly on the single antenna element and mutual coupling effects between the antenna units of the array when all other elements are excited. The feed architecture shown in Figure 2 reduces the frequency-dependent variations in input impedance. So the input impedance does not depend on the machining accuracy largely. In [7], a compact, ultra-wideband structure is presented, but E-plane bends and E-plane tees are only used in junctions of the feed network, impedance transformation are not utilized in the arms of powder divider. A True-Time-Delay feed is illustrated in [8]. In order to improve the impedance matching, some matching methods are adopted in this structure. The inductive grooves formed in the parallel-plate structure opposite the input arm and the tuning wells formed on the wall opposite the input arm are all to provide matching function. However, many turning variables make it hard improve the impedance matching.

2.3 The Linear Source

The antenna in this paper is fed by linear source. Either a discrete linear array or a continuous linear source is adapted. For example, slot waveguide and H-Plane horn may be used. A linear source is proposed in this letter, which makes used of the offset parabolic cylindrical reflector, shown in figure 3. The whole framework comprises parallel-plate waveguide, H-horn and a parabolic reflector. H-horn and reflector are placed in interior of the parallel-plate waveguide, and the heights of them are equal. The parabolic cylindrical reflector is illuminated by the H-plane Sectoral Horn and the phase centre of the horn is fixed at the focus of the reflector.

3. Simulated Results

Figure 4 shows the cross section for a portion of radiators of continuous transverse stub air-filled array antenna. The multi-stage combination of parallel-plate waveguide designed here provided a wideband impedance matching between waveguide and free-space. The proposed array antenna is shown in Figure 4, and consists of a linear-source, feed network and radiating cells. The size of antenna aperture is about 500mm×500mm. This array consists of 16 radiating units, distance of element is half of centre frequency (10GHz) wavelength (λ_0). The key issues of this type CTS antenna are powder divider. The feed network for CTS antenna array includes a plurality of feed level and multi-stage impedance transformer shown in Fig.2. The width of input is 5.08mm. Multi-stage impedance transformer are designed based Chebyshev Impedance Transformation Theory, and the final dimension is determined through simulation and optimization. Radiation patterns of the antenna fed by ideal feed (without linear source) at 8GHz and 12GHz are shown in Figure 5 and Figure 6. Return losses of the antenna with linear source fed are shown in Figure 7 and Figure 8, the operating frequency-band are 7.2GHz to 8.4GHz and 11.5GHz to 13GHz. The gain pattern in E-plane at 8GHz and 12GHz are shown in Fig.9 and Fig.10 respectively. The pattern appears that the gain is 28.24dB at 8GHz and 33.11dB at 12GHz and normalized side lobe level are -16.2dB and -15.8dB respectively.

4. Conclusion

A CTS array antenna is designed and analyzed in this paper. By using multi-stage impedance transformer in radiating element and feed network to improve radiation efficiency and reduce the height compared with other forms of parallel-fed CTS array antenna. And a fine gain and a low side lobe are obtained. For its potential characteristics, the proposed CTS antenna can be applied in wireless communication systems at millimetre-waves.

Acknowledgments

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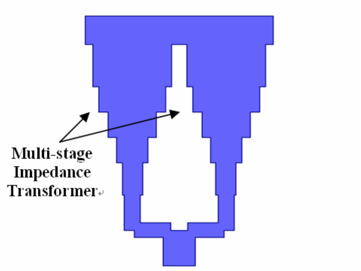


Figure 1: The Radiating element

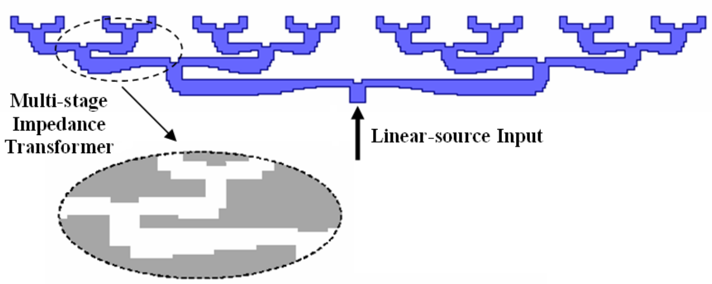
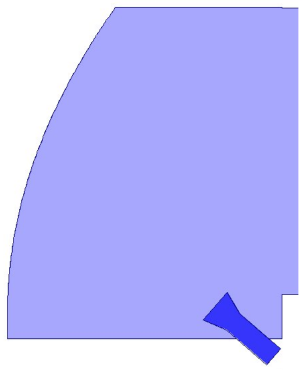


Figure 2: The cross-section view of power divider



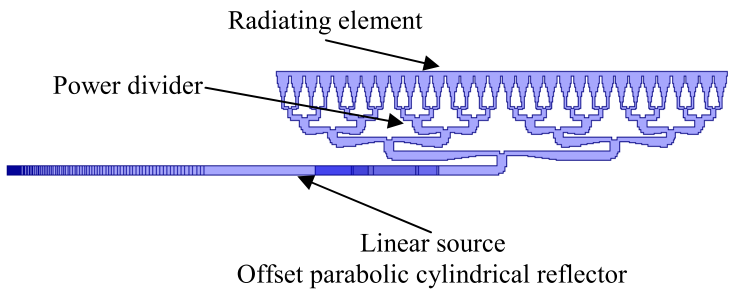


Figure 3: The Linear source

Figure 4: The proposed CTS array antenna

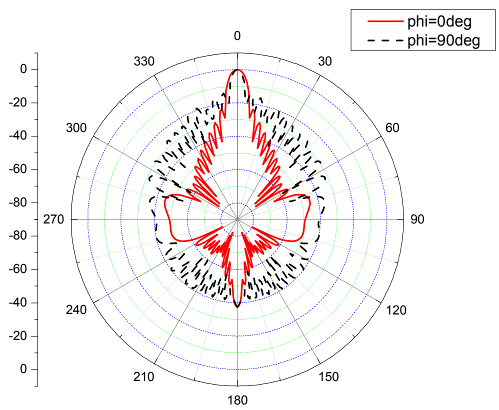


Figure5: Radiation pattern at 8GHz

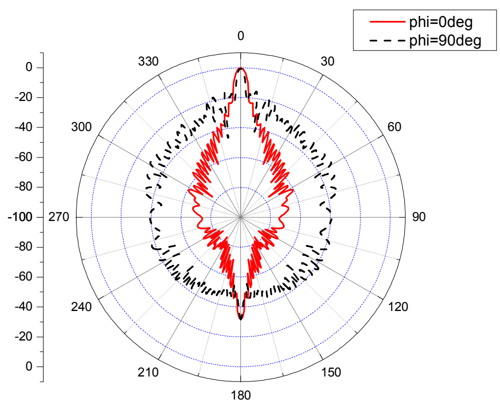


Figure6: Radiation pattern at 12GHz

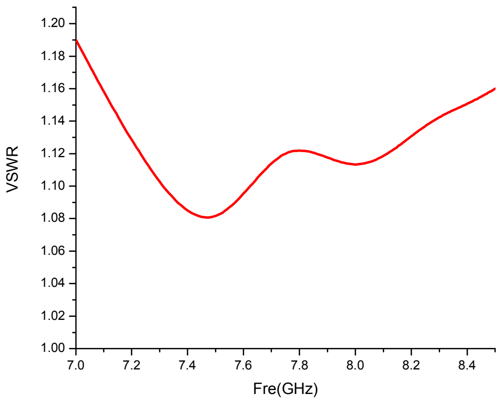


Figure7: Simulated VSWR

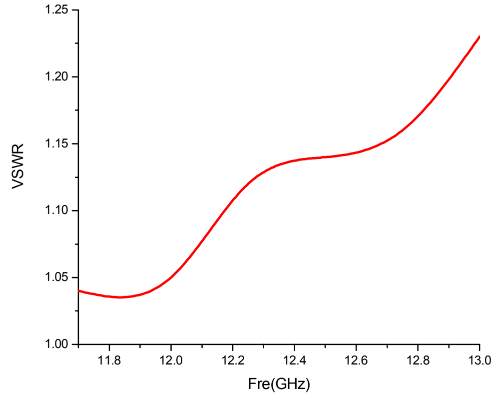


Figure8: Simulated VSWR

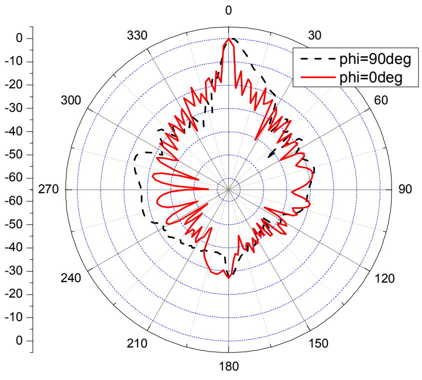


Figure9: Radiation pattern at 8GHz

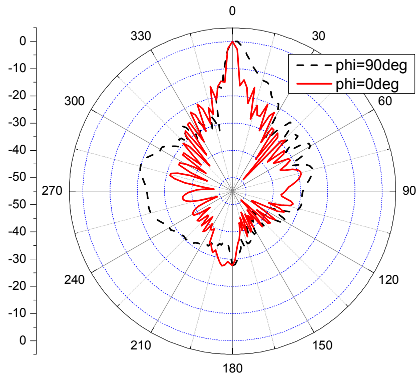


Figure10: Radiation pattern at 12GHz

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