

UWB Antenna Array with Comb Taper Slot Antenna Elements

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Abstract

A uniformly spaced comb taper slot antenna array is proposed for directional ultra-wideband (UWB) applications. The UWB array consists of four identical comb taper slot antennas, a multi-stage with four-way microstrip UWB power divider, and four identical coaxial cable lines. A maximum gain of 15.5dBi within the band is obtained when the element separation is properly selected. The uniform spacing between adjacent array elements is 2.5 cm in the H-plane. The performance of the antenna array and the other important parameters are investigated. It is proved experimentally that the proposed antenna array is suitable for the directional UWB antenna array.

Keyword: UWB, antenna array, comb taper slot antenna

1. Introduction

UWB systems are mainly limited by the strict power regulations, which protect the wireless systems assigned to frequencies within the UWB band. A UWB system is required to operate at very low power level [1], which limits its transmission range. For some communication and radar applications, directional UWB antennas with high gains are needed in order to enhance the quality of communication link and transmission range. One solution is the usage of the antenna array [2].

Among antenna configurations that are currently considered as candidate elements for UWB arrays [3~4], such as the bow-tie antenna, the log-periodic dipole array antenna, the spiral antenna, the TEM horn antenna, and the double ridged horn antenna, etc., the taper slot antenna (TSA) is well known as having traveling wave operation, low weight, thin structure, easy of fabrication, and is well suited for microwave integrated circuits (MICs) and expected for the applications described above. The performance of the UWB feeding circuit is also critical for the antenna array design. The feeding circuit in this case is using a UWB power divider with equal amplitude/phase weighting [5] ~ [7].

In this paper, a uniformly spaced linear UWB array is studied. The UWB array is composed of four identical UWB comb taper slot antenna elements, a multi-stage with four-way microstrip UWB power divider and four identical cable lines. They are discussed in the following sections.

2. UWB Comb Taper Slot Antenna and Power Divider

The geometry of the comb taper slot antenna is shown in Fig. 1. The antenna can achieve ultra-wideband performance due to its elegant transition from microstrip line. The microstrip transition at the input is tapered circularly to parallel strips for the antenna feed. The flare is taper exponentially with the opening rate determined using the recursive optimization in CST Microwave Studio. The corrugations along the sides serve to reduce the antenna width, improve the voltage standing-wave ratio (VSWR) over a wide frequency range, and to suppress the sidelobe levels [8~10]. The antenna is designed on an FR4 substrate with relative permittivity of 4.4, thickness of 0.8mm, and loss tangent of 0.0254. The size of the antenna is 140 by 40 mm².

In order to realize the characteristics of UWB power divider, a five-step Chebyshev transformer as shown in Fig. 2 is designed to match the four output impedance. The power divider was fabricated using microstrip lines on an FR4 substrate with relative permittivity of 4.4, thickness of 1.6mm, and loss tangent of 0.0254. The size of the power divider is 44.2 by 31.22 mm². The measured return loss at port 1 and insertion losses S₂₁, S₃₁, S₄₁, and S₅₁ are shown in Fig.3. The insertion losses from the input to the four outputs are varying between 8 and 11 dB for frequencies between 3.1 to 10.6GHz. The operation bandwidth is 107 % with return loss of 9 dB. The phase linearity for S₂₁, S₃₁, S₄₁, and S₅₁ are shown in Fig.4. The maximum phase deviation from the linear phase is about 10 degrees for the whole band.

3. The Prototype of the UWB Antenna Arrays

The prototype of the proposed UWB antenna array with element separation of 2.5cm is shown in Fig. 5. The gain and radiation pattern of the antenna array are critically dependent on the separation between the two adjacent elements. Antenna element spacing cannot be larger than one wavelength in H-plane for reducing the grating lobes if the system will be used in frequency domain communication system. Fig. 6 shows that the measured return loss is larger than 8 dB across the 3.2~10.6 GHz band. Figs. 7 and 8 show the measured H-plane and E-plane patterns at 4, 7 and 10 GHz. The measured H-plane gains of the single element and the array are given in Fig. 9. The gain varies from 9.2 to 15.5 dBi over the entire operation band.

4. Conclusions

A high gain UWB antenna array has been studied and implemented. The core technologies of this study include the system design, UWB comb taper slot antenna element, multi-stage with four-way microstrip UWB power divider, and four identical cable lines. Detail design will be discussed during the presentation. The proposed antenna has been verified experimentally and can be successfully used in other applications such as the radar system, microwave imaging, and others.

Acknowledgment

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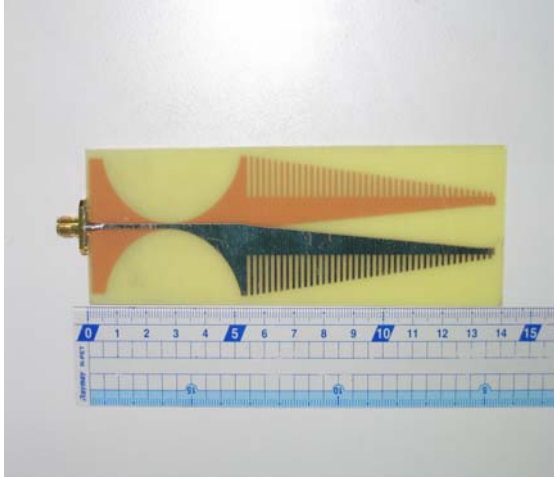


Fig. 1: The comb taper slot antenna

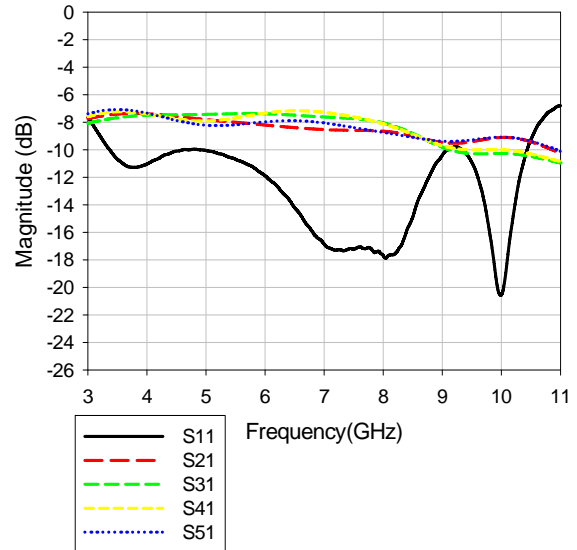


Fig. 3: Magnitude of S-parameters of the UWB power divider

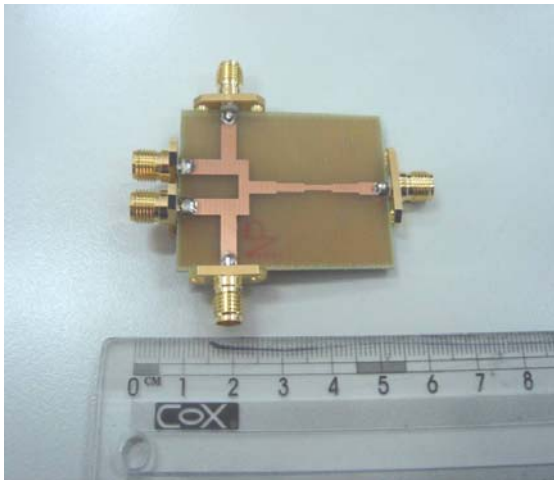


Fig. 2: The UWB power divider

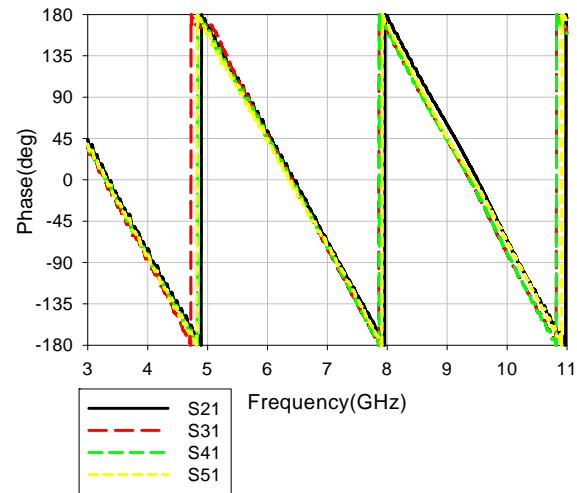


Fig. 4: Phase of S-parameters of the UWB power divider

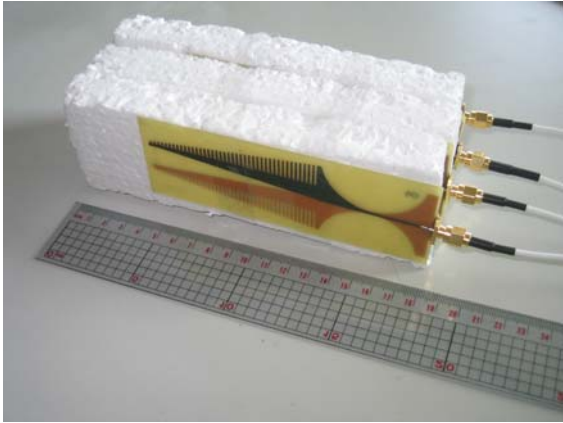


Fig. 5: The UWB antenna array

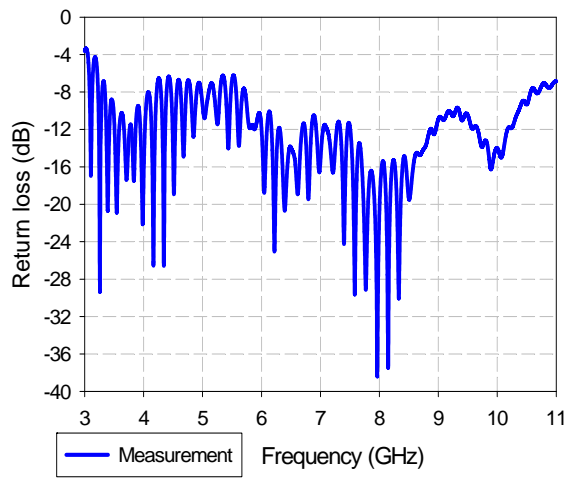


Fig. 6: Measured return losses of the proposed antenna array

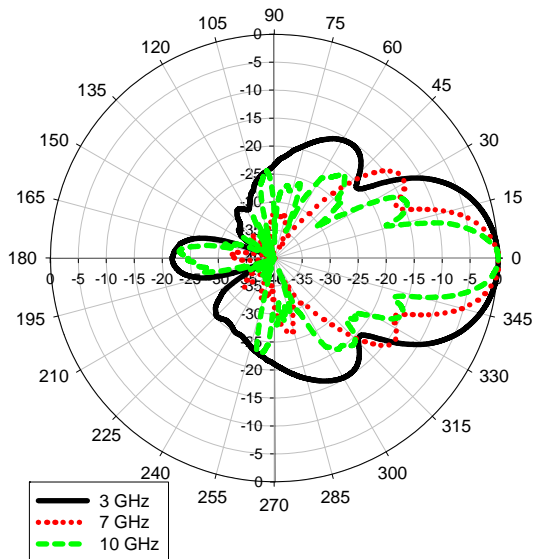


Fig. 7: Measured H-plane pattern of the UWB antenna array

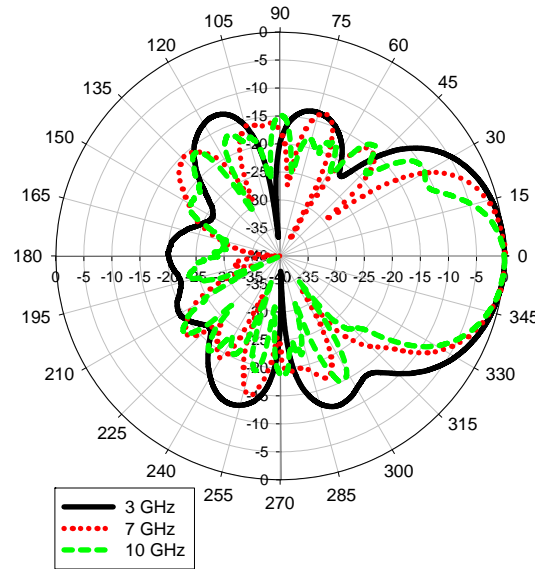


Fig. 8: Measured E-plane pattern of the UWB antenna array

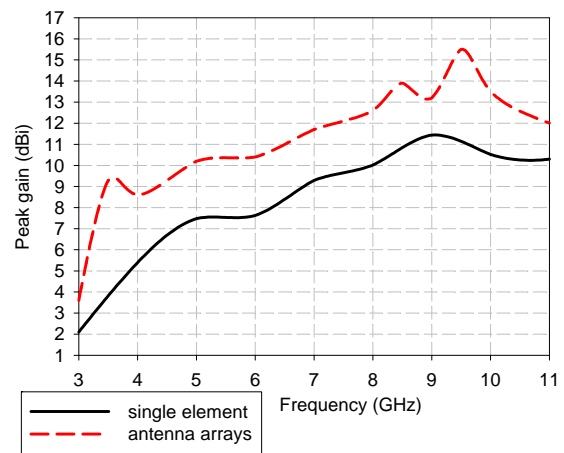


Fig. 9: Measured gains of single element and arrays