A High-Efficiency Ultral-Wideband Dual-Polarization Array Antenna

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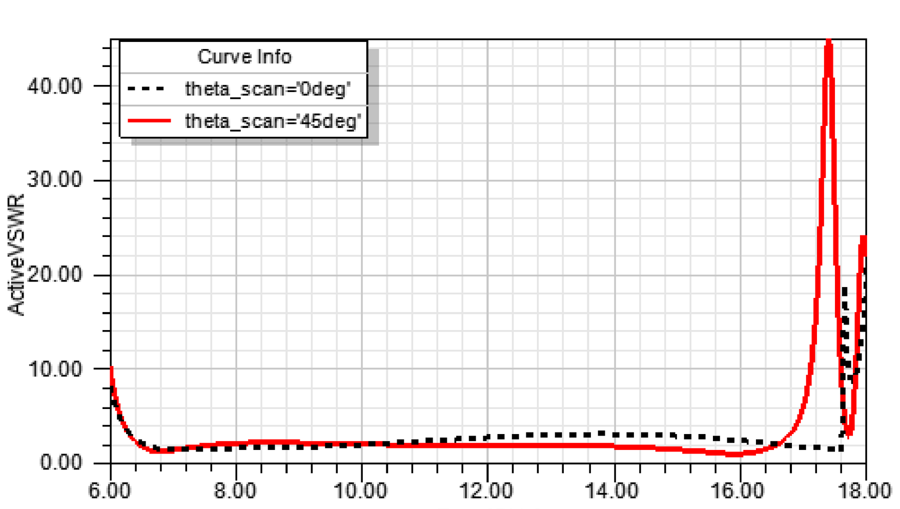
Abstract

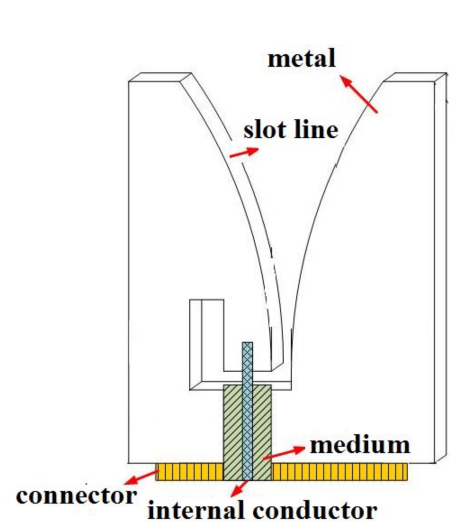
The ultra-wideband(UWB) large-angle scan array antenna is the base of electronic countermeasures and wideband radar. Almost the ultra-wideband array are the tightly coupled array, and all the antenna element spacing of the array is less than half a wavelength of highest frequency. A new 3:1 bandwidth dual-polarization tightly coupled array antenna is designed. The new antenna is a pure metal vivaldi antenna, and it's feed by the inner conductor of a RF connector directly. The antenna element spacing is bigger than half a wavelength of highest frequency, by adjust the thickness of the antenna to enhance the coupling between antenna elements, which means the antenna has higher efficiency. By use two-dimensional periodic boundary in HFSS, the antenna is simulated and optimized. The antenna is measured, the active-VSWRs at 6-18GHz are blew 3, the unweighted side lobe is less than -13dB, and the cross-polarization within the operation band are better than -25dB.

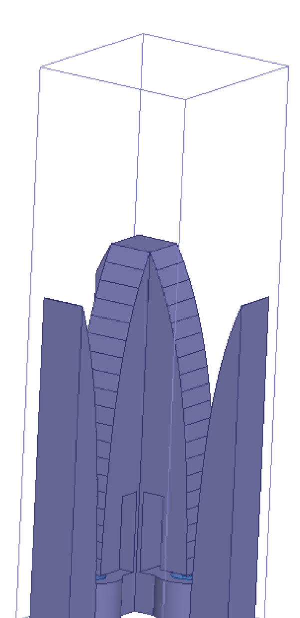
Structure

The conventional vivaldi antenna is processed by a copper coated dielectric substrate, which is suitable as the UWB large-angle scan array, with some advantages such as simple structure, ultra-wideband, small volume.

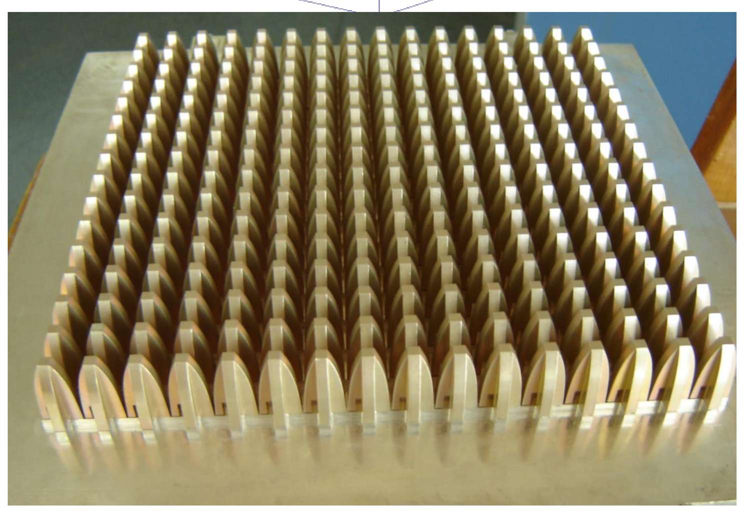
The vivaldi antenna array is the tightly coupled array, and the element spacing (d) is usually no more than half of the work minimum wavelength (λmin) . Equation (1) is the maximum element spacing when scan with no grating lobe, and the θmax is the maximum scan angle. Accord to (1), the maximum element spacing when scan 45deg can be 0.586λmin, which is bigger than 0.5λmin. If the element spacing could achieve 0.586λmin, the system will save 27.2% antenna elements and RF channels . But for the conventional vivaldi array, if the element spacing is 0.586λmin, there's a singularity of active-VSWR at high frequency, as shown in Fig. 1. The position of the singularity will change with different scan angles and element spacing.

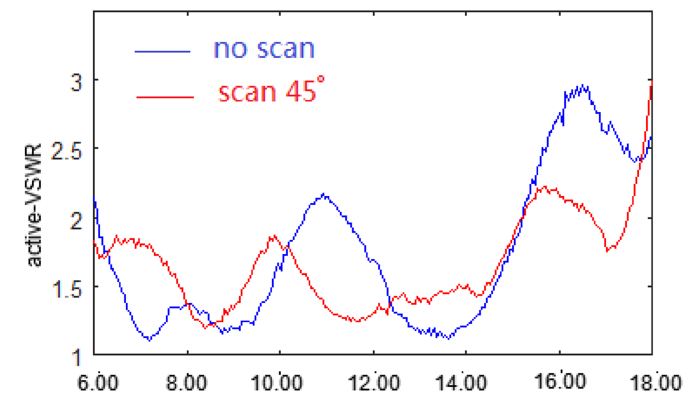






The new vivaldi array antenna is also a tightly coupled array. But it's an all-metal antenna, the thickness and the shape of it can be adjusted. By increase the thickness of the antenna, when the element spacing (d) is bigger than 0.5λmin, the distance between two adjacent elements faces (d1) could be still smaller than 0.5λmin, as shown in Fig. 3. So the couple between two elements could be still tightly and the active-VSWR results still be ok.

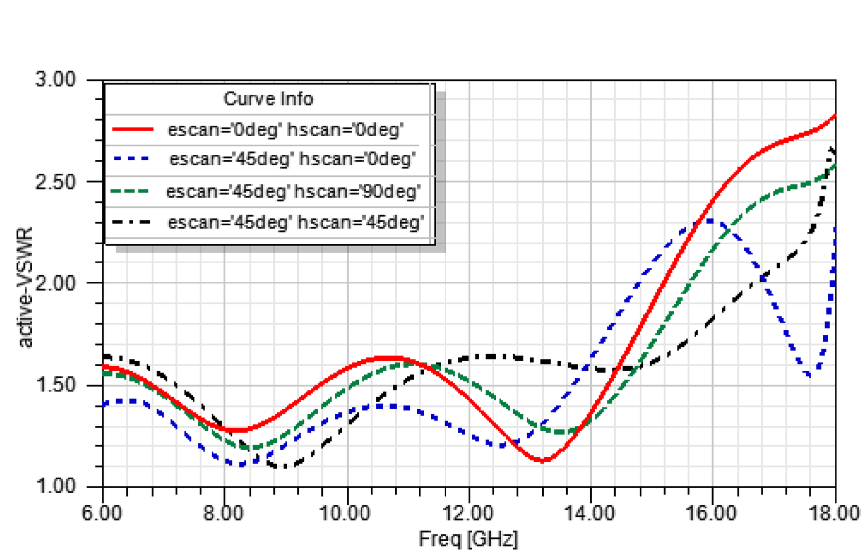


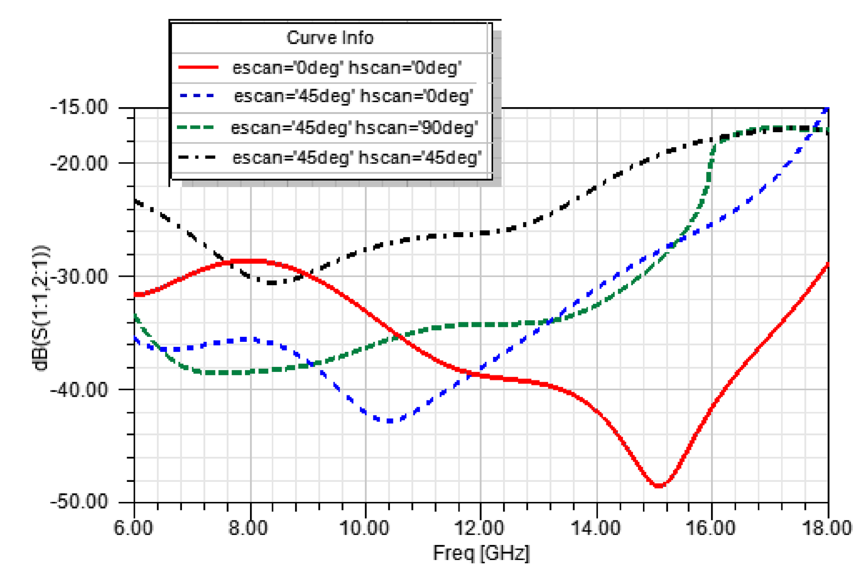


Simulation

For ultra-wideband tightly coupled array antennas, due to the serious mutual coupling between the antenna elements, the passive standing wave of a single antenna element is very different from the active standing wave of the element in the array. The two -dimensional periodic boundary method in HFSS software can be used to quickly simulate and optimize the performance of elements in the array, as shown in Fig. 4.

Fig. 5 are the active standing wave results with different scan angles of the antenna element in the array. The read real line, the green dashed line, the blue dotted line, the black dotted point line are the active standing wave results of the antenna of no scanning, azimuth scanning 45 degrees, pitch scanning 45 degrees and oblique scanning. It can be seen that the active standing waves at all scanning angles are less than 3 in the 3:1 bandwidth. Fig. 6 are the isolation results between two polarized ports, and the value are less than -15dB at all scanning angles in the 3:1 bandwidth.





Results

Fig. 7 is the photo of the antenna array. In order to understand the performance state of the antenna array in practice, the active standing wave of the antenna array is tested. The specific test method is as follows: by testing and recording the coupling S12 of the measured element and all other elements of the array, the active standing wave of the measured unit can be calculated by formula 2. Fig. 8. are the active standing wave measured results of no scanning and scanning 45 degrees, and the value at all scanning angles in the 3:1 bandwidth are less than 3. The planar near field method is used to measure the lobe pattern of antenna array in microwave anechoic chamber. The antenna is synthesized and scanned by power splitter and phase distribution cable. Fig. 9 and Fig. 10 are the lobe patterns of the antenna array at 6GHz, 12GHz and 18GHz of no scan and scan 45 degrees. The side-lobes of no scan and scan 45 degrees are less than -12 dB, and the cross polarization are under -20 dB.

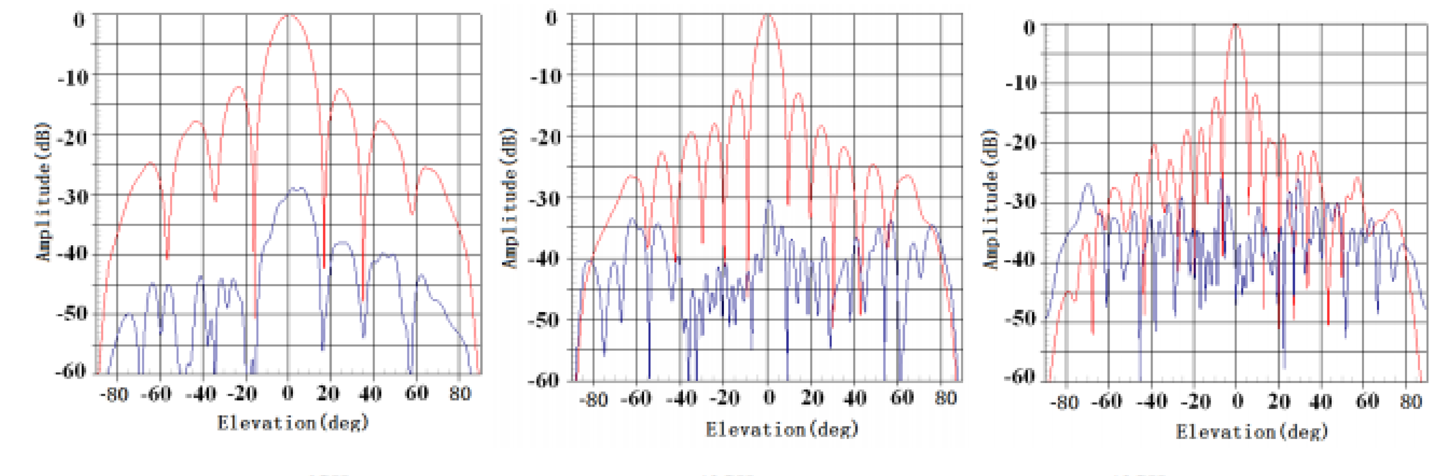


Figure.9 Lobe patterns with no scan.

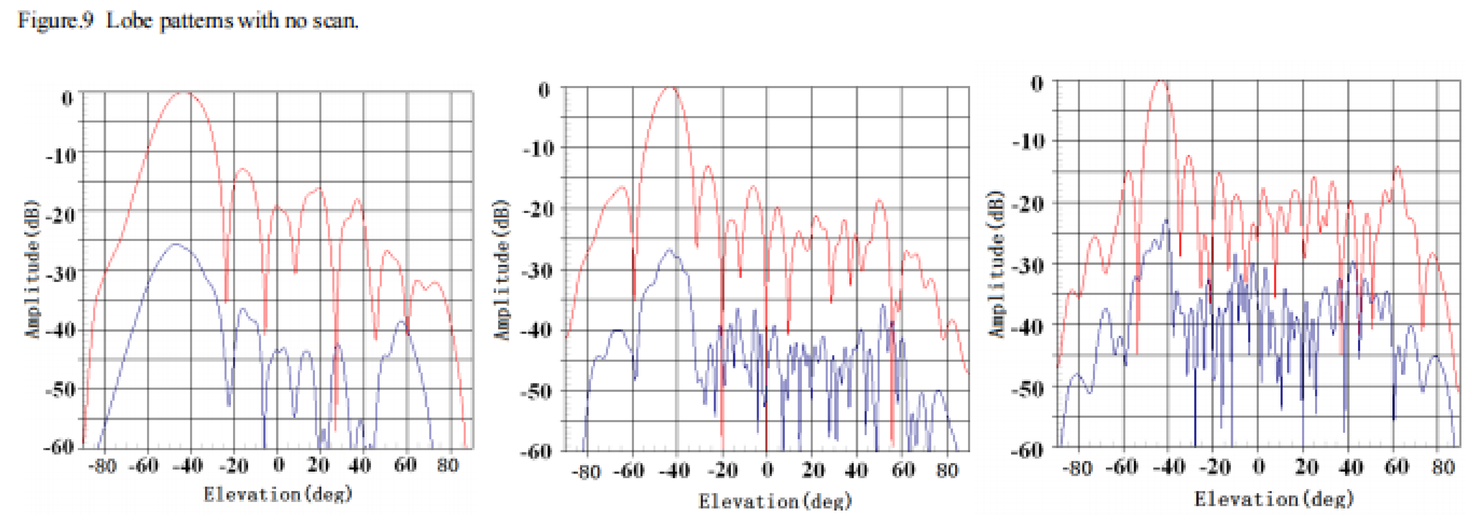


Figure .10 Lobe patterns with scan 45 °

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