Rectangular Slot Array Antenna

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***Abstract*—Slot antenna elements are quite popular for use in flat-panel arrays, due to their compactness and relatively large bandwidth. According to Babinet's Principle, slots and dipoles are duals in performance. Therefore, a vertically placed slot is horizontally polarized and a horizontally placed slot is vertically polarized. A rectangular slot array lends itself to a broad range of applications, e.g., tactical and weather radar. Such arrays can be gimbaled to point their beam in any azimuth and elevation angle of interest. In this effort, a slot antenna element is designed in WIPL-D Pro to operate over the 7.5 - 8.5 GHz frequency range. The element is designed to resonate at 8 GHz. The slot element is used to generate a 6x12 slot array normal to the xy-plane. Separate Taylor tapers (nbar = 5) are applied to the 6-row and 12-column elements to provide 25 dB and 30 dB sidelobe level (SLL) suppression, respectively. The input impedance and pattern performance for a single slot, as well as the slot array's radiation performance show excellent broadband performance.**

Keywords*—*Array, broadband, sidelobe, slot, taylor taper, WIPL-D.

I. INTRODUCTION

A slot antenna is a very useful type of antenna for specific applications. Its duality with respect to a dipole (Babinet's Principle) is one of its primary features, especially when a vertically oriented, horizontally polarized antenna is required. When a large number of half-wave dipoles is used to produce a horizontally polarized array, the width of the array may become physically untenable. On the other hand, a similar array built from half-wave slots would be vertically oriented, allowing for a much larger number of slot elements to be included in the same available space.

A common application for slot arrays is in horizontally polarized tactical and weather radar, where the array is positioned normal to the xy-plane. The need for a much narrow azimuth beamwidth (BW) relative to the elevation BW, lends itself quite well for the use of vertical slot arrays. In such a configuration, a large number of elements in each row and a much smaller number of elements in each column are used to produce a narrow azimuth beam and wider elevation beam (known as a fan beam), respectively.

According to Babinet's Principle, a center-fed half-wave thin slot placed in an infinite Perfect Electric Conductor (PEC) plane is the dual of a center-fed half-wave dipole of infinitesimal wire radius. The input impedance of the slot is related to that of the half-wave dipole as provided in [1]. The resulting input impedance is very high, hence poorly matched to 50 W. Moreover, in order for a slot to be useful in antenna array applications, a slot element must be confined to a finite space. Those elements can then be duplicated to form an array with properties unique to the application at hand.

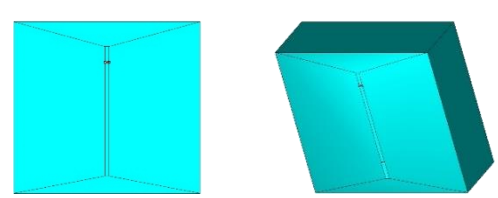
In this effort, a self-contained slot antenna is designed in WIPL-D Pro [2]. The self-contained slot is then used to design a 6x12 vertical slot array. Separate Taylor tapers (nbar = 5; Number of nearly constant adjacent sidelobes) are applied to the 6-row and 12-column elements to provide 25 dB and 30 dB sidelobe levels (SLLs), respectively.

II. MODELING EFFORT DETAILS

A. Slot Antenna and Array Design and Modeling

A self-contained slot antenna (antenna from hereon), as shown in Fig. 1, was designed in WIPL-D for an 8 GHz center frequency and a 7.5 - 8.5 GHz frequency range of operation. The slot length was set to half-wave at 8 GHz, while its width was set to 0.015l. The slot feed location was swept from its center towards one end until a perfect match to 50 W at 8 GHz was achieved. The slot was designed to be self-contained in a rectangular box. The backplane of the box was set to 0.25l at 8 GHz, for best boresight performance. The height and width of the box were arbitrarily chosen and each set to 1″.

The antenna input impedance and VSWR performance, from 7.5 – 8.5 GHz, are shown in Fig. 2. Principal azimuth and elevation cut overlays at 7.5, 8 and 8.5 GHz are shown in Figs. 3 and 4, respectively.



(a) (b)

Fig. 1. Slot antenna model: (a) front view; (b) isometric view.

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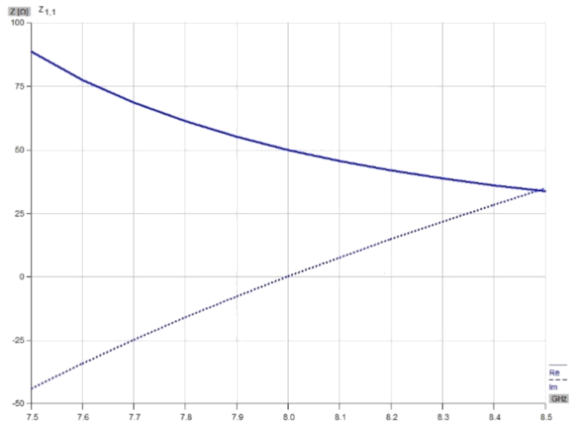
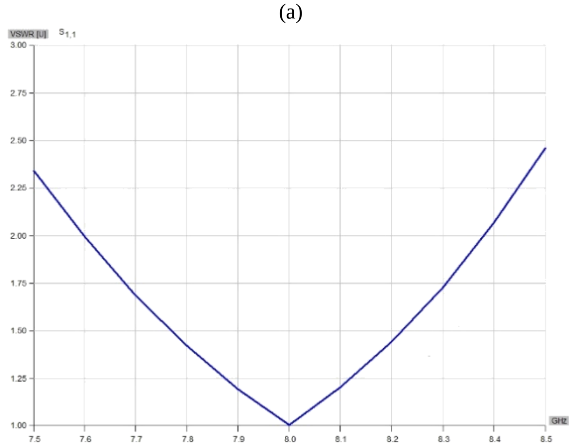


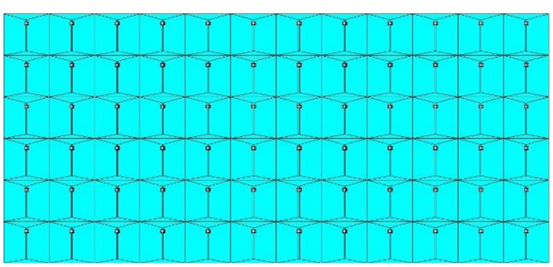
(a)



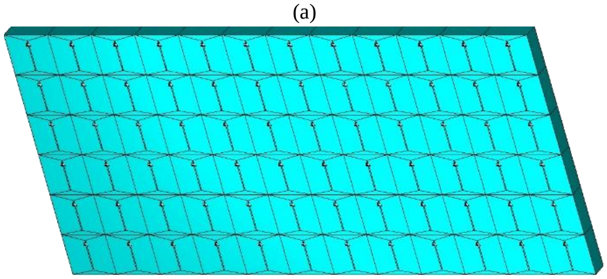
(b)

Fig. 2. Slot antenna parameters: (a) input impedance; (b) VSWR.

A slot array was then formed by copying the one slot element model five times to form one 6-element column sub-array. Then the entire 6-element column was grouped and copied 11 times to form the entire 6x12 (6″x12″) slot array, as shown in Fig. 3.



(a)



(b)

Fig. 3. Slot antenna array model: (a) front view; (b) isometric view.

The slot array's Principal azimuth and elevation cut overlays at 7.5, 8 and 8.5 GHz are shown in Figs. 4 and 5, respectively.

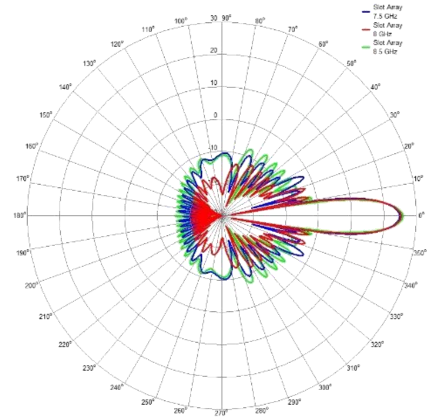


Fig. 4. Slot array principal azimuth cut overlays.

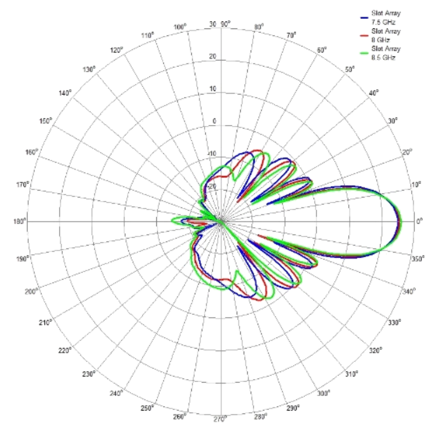


Fig. 4. Slot array principal elevation cut overlays.

III. Conclusions

A compact self-contained slot antenna element is designed to provide directional boresight radiation and good impedance matching to 50 W, over a relatively broad range of frequencies. Due to its compact size, the slot element is used to produce a 6x12 element array that fit within a 6″x12″ space, respectively. The array exhibits consistent azimuth and elevation gain, BW and SLL performance relative to the design parameters, across the entire 7.5 – 8.5 GHz frequency range of operation.

References

[1] C. A. Balanis, Antenna Theory– Analysis and Design. 4th Edition, Hoboken, NJ: John Wiley and Sons, 2016, pp. 680-684.

[2] WIPL-D Pro, Software and User's Manual, WIPL-D d.o.o., Belgrade, 2019.