# Simple Design Procedure for 2D SWAs with Specified Sidelobe Levels and Inclined Coupling Slots

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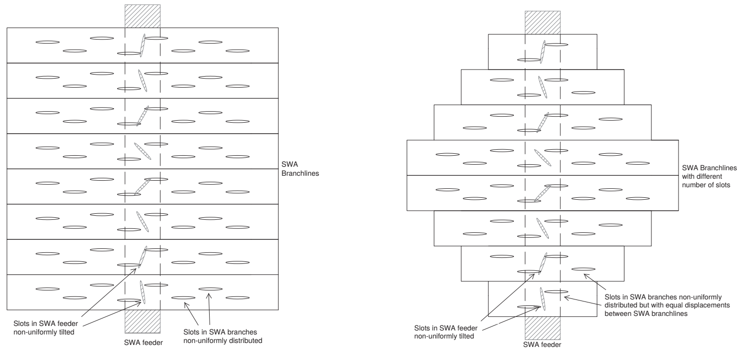
**Abstract**— A simple procedure for the design of two-dimensional SWA array systems with desired sidelobe level ratio (SLR) is presented. The described procedure finds the slots length, width, locations and displacements from the centerline, for each branch waveguide. For a specified number of branch waveguides, the method also finds the rotation angle of each of the coupling slots. To explain the controllable SLR, two 2D SWA array systems designed for an SLR higher than 20 dB are illustrated and compared.

Slotted Waveguide Antennas (SWAs) radiate energy through slots cut in a broad or narrow wall of a rectangular waveguide. They offer clear advantages in terms of their design, weight, volume, power handling, directivity, and efficiency. For broad-wall SWAs, the slot displacements from the wall centerline determine the antenna's sidelobe level (SLL). In addition, the rotation angle of the coupling slot in a 2D system array of SWAs determines the power fed by each slot into each branch-line SWA. Inclined coupling slots have found their interest as the radiating elements used in the main feeder to couple the power to the SWA branch-lines in two-dimensional (2D) SWA array systems. Based on the procedure described by Elliott and Stevenson in [1, 2, 3], Bhatti *et al.* designed a planar slotted waveguide array antenna for X-band radar applications having a diamond shape[4].

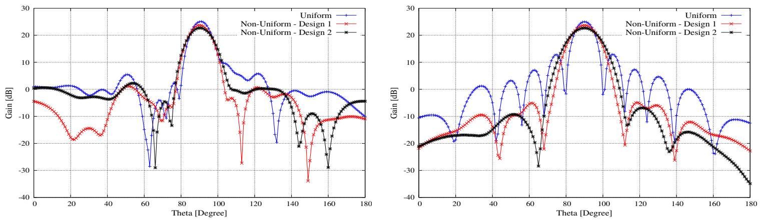
In comparison to the previous work done, this paper presents a simple procedure for the design of a two-dimensional (2D) SWA array system with a desired sidelobe level ratio (SLR), and study the effect of having a diamond shape array system. The system proposed here consists of multiple branchline waveguides with broadwall radiating shunt slots, designed as per the guidelines described by the author in [5]. A main waveguide is used to feed the branch waveguides through a series of inclined coupling slots with well-defined rotation angles for low SLLs. For a specified number of identical longitudinal slots, the described procedure finds the slots length, width, locations along the length of the waveguide, and displacements from the centerline, for each branch waveguide. Furthermore, for a specified number of branch waveguides, the method finds the rotation angle of each of the coupling slots. To explain the controllable-sidelobe 2D SWA design procedure, two 2D SWA array designs are studied. An SWA with $8 \times 8$ elliptical slots, designed for an SLL lower than $-20$ dB, is taken as an example. An 8-element 1D SWA with a desired SLL is designed first. Eight identical such SWAs are then attached side by side in the first design. The proper design of the 1D SWAs ensures having the desired SLL in one principal plane. To enforce the same SLL over the whole 3D pattern, special care should be given to the design of the feed SWA, whose slots should power the radiating SWAs according to a correct distribution. For the taken example, the feed SWA should have 8 slots, separated consecutively by a distance related to the radiating SWA aperture width and wall thickness. The power fed by each slot in the feeder and fed to the branchline waveguide is controlled by the inclination angle of the coupling slot. The second design varies the design of the SWA branchlines and slots displacements and studies the comparison between the illustrated examples. The simulations results for both designs are reported and compared.

Designs 1 and 2 are shown in Figure 1, they both operate at a frequency of 4.021 GHz. The gain pattern comparison of the three designs are shown in Figure 2, with a detailed comparison listed in Table 1. As inspected, Designs 1 and 2 both achieve very low SLRs in both E- and H-planes compared to the uniform case. Studying the effect of having a planar diamond shape in Design 2, proposed in the literature such in [4], different observations have been depicted. For instance, Design 2 achieved better results in terms of SLR in H-plane, however, Design 1 outperforms Design 2 in terms of SLR in E-plane, and HPBW in both planes, and total gain. Hence, no valuable improvements have been seen as a result of using such diamond configurations. Nevertheless, the




(a) (b)

Figure 1: 2D Systems, (a) Design 1, (b) Design 2.




(a) (b)

Figure 2: Compared gain pattern results of the uniform and non-uniform displacements and rotation angles Design 1 and Design 2 cases: (b) E-plane, (c) H-plane.

Table 1: Compared HPBW and SLR results of uniform case, Design 1 and Design 2 array designs

| System | E-plane | | H-plane | | Gain (dB) |
|---|---|---|---|---|---|
| | HPBW (°) | SLR (dB) | HPBW (°) | SLR (dB) | |
| Design 1 | 10.2 | 22.5 | 12.6 | 28.8 | 23.7 |
| Design 2 | 11.1 | 20.4 | 14.9 | 32 | 22.7 |
| Uniform | 7.9 | 19.6 | 9.2 | 12.3 | 25 |

increment of HPBW in the proposed designs here is higher than that of the uniform, and this is normal because of the decrement in the SLL values. Hence, in this paper, a simple design procedure for 2D SWA arrays with desired SLRs have been illustrated using non-uniform inclined coupling slots in the main feeder, and longitudinal shunt slots in the radiating branches. The two example illustrated resulted in SLR values of higher than 20 dB.

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