Miniaturized Slotted Waveguide Antennas with Periodic Structures for HPM Applications

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***Abstract*—This work describes the use of periodic structures for the size reduction of slotted waveguide antennas (SWAs) having slots in either a narrow or a broad waveguide wall. SWAs are attractive for their high-power handling, design simplicity and high efficiency, but their size can grow very large. Periodic structures designed from metamaterial cells or corrugations help compact the size. They offer other advantages, such as better matching at the feed.**

I. Introduction

Slotted waveguide antennas (SWAs) are attractive due to their design simplicity and their significant advantages in terms of high power handling, high efficiency and good reflection coefficient. The size of an SWA is usually large, since it is an array of slots, with constraints on the spacing between adjacent slots. For higher gains and better radiation characteristics, an SWA with more slots is required, meaning an even larger size. Periodic structures, on the other hand, have been extensively researched in the area of antenna engineering, with main applications in gain enhancement, frequency selection, and interference and sidelobe suppression.

In this work, periodic structures based on split-ring resonators (SRRs) and metal corrugations are shown to be very effective in compacting the size of SWAs with slots in either the narrow or broad waveguide walls. They can also be applied for efficient matching at the antenna's feed. Both advantages are important for high-power microwave (HPM) applications.

II. Narrow-wall SWAs Loaded with Metamaterials

Narrow-wall longitudinal-aperture waveguide antennas have drawn increasing attention in HPM applications due to their better power handling ability. However, there exist more constraints on the narrow-wall aperture placement, so size reduction is a major concern for narrow-wall SWA design.

Previous work has been done on narrow-wall SWA designs. An example design achieves a fan-beam radiation pattern with a reflection coefficient less than -30 dB, but has a large size. Upon introducing SRR-based metamaterials inside narrow-wall SWA designs, size reduction is achieved.

An SRR array is inserted into a size-reduced HPB-radiator-loaded SWA, which leads to a further transverse aperture size reduction of about 70%, compared to the conventional case. The new SRR-loaded narrow-wall SWA maintains a fan-beam radiation pattern with high directivity. For high-power handling, the ring arrangement is optimized to maintain a low reflection coefficient and a high radiation efficiency.

III. Broad-wall SWAs with Periodic Structures

Two identical sets of metallic corrugations are added inside an S-band SWA having 10 elliptical slots on one broad-wall and designed for 3 GHz and a sidelobe level (SLL) of less than -30 dB. A first configuration of the corrugations, with optimized number, spacing, and height (height is about $b/1.5$), offers a resonance at a lower frequency, 2.55 GHz instead of 3 GHz. This translates into a reduction in the waveguide length by about 46%. The gain and SLL are almost unchanged. A second corrugation configuration, which differs in the corrugations spacing and height (height now is lower, about $b/4$), keeps the same resonance at 3 GHz but leads to a very low reflection coefficient (-48 dB compared to -18 dB for the non-corrugated version).

With the corrugations, the size reduction was in term of the waveguide length only. Further transversal compactness, that includes smaller a and b values, can be obtained upon the use of a periodic set of metamaterial cells, mainly SRRs. The loading of the SWA by both the corrugations and the SRRs is investigated.

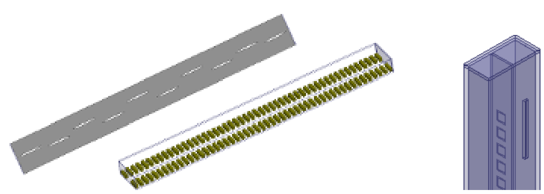
(a) (b)

Fig. 1: Broad-wall SWA with: (a) corrugations (b) SRRs.

IV. Conclusion

This work showed the use of periodic corrugations and SRR-based metamaterials for size reduction of both broad- and narrow-wall SWAs. Better reflection coefficients and high radiation efficiencies can also be achieved. These SWAs loaded with periodic structures are suitable for HPM applications.