New isolation design of folded waveguides for a monopulse waveguide slot-array antenna

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Abstract

A new isolation design of folded waveguides for a monopulse waveguide slot-array antenna is proposed. A slot-array antenna using monopulse techniques generally has the four quadrants electrically divided by PEC walls. However, the new folded waveguides presented in this paper have no PEC walls and thus provide an ease of manufacturing and removing a filler metal after dip brazing.

Keywords : Slot-array antenna Folded waveguide Monopulse dip brazing

1. Introduction

The waveguide slot-array antennas have frequently been applied to radar systems requiring narrow beamwidth and high directional beam pattern. Particularly, it is more useful in airborne radar systems because of its light weight and small scan volume.

The waveguide slot-array antenna system mounted on aerial vehicles widely uses monopulse techniques to track a target moving toward arbitrary direction. For monopulse signals, the antenna system consists of two big parts. One is the radiation part electrically divided into four sections. The other is the feed network which makes sum, azimuth difference, and elevation difference signal from sources received through four quadrants of the radiation part [1].

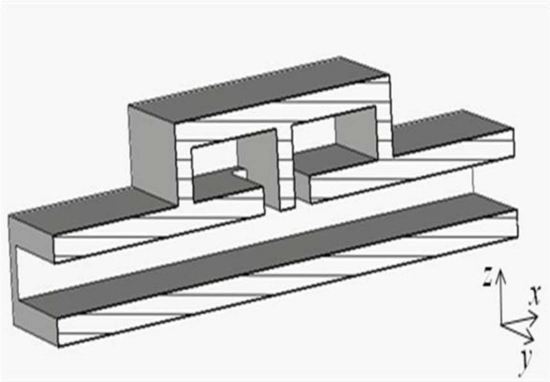
In radiation part, each section has its own feeding waveguide beneath radiation slot waveguides. Where two feeding waveguides meet end-to-end, there is not enough space for each waveguide because last slot in a feeding waveguide keeps $\lambda_g / 2$ distance from the short circuit wall of the feeding waveguide [2]. Therefore, it is necessary to fold the short circuit wall. Generally there is a Perfect Electric Conductor (PEC) wall at a place where two feeding waveguides meet end-to-end due to the isolation between each section of the radiation part. However, in the manufacture process the PEC wall induces sludge of filler metal which deteriorates electric performance and disturbs flows of cleaning flux after dip brazing.

In this paper, we propose the new folded waveguides without PEC walls. It offers an easy way to manufacture and to remove a filler metal while it still maintains the same electrical characteristics as conventional model. In order to verify the effectiveness of the new folded waveguides an antenna, which has the proposed model, is fabricated and measured.

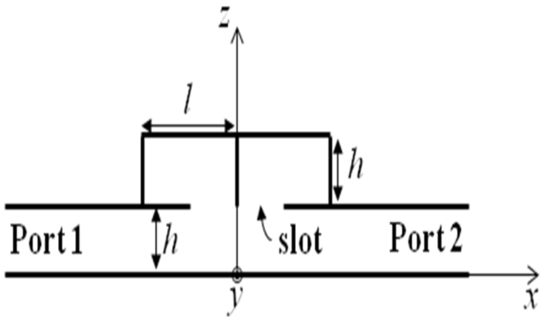
In the following Section 2, the proposed folded waveguide is shown. Then, simulated results by CST(Commercial numerical software) are compared with the measured data for new folded waveguide applied antenna in Section 3. Finally, conclusion is given in Section 4.

2. Proposed Structure And Simulation Results

The new folded waveguide is depicted in Fig. 1. Two same folded waveguides are connected end-to-end at x=0 as shown in Fig.1 (b). In general, a PEC wall is located at x=0 because it has to be completely electrically isolated from each other. In the new model optimized slots increase coupling between feed waveguide and cavity to prevent a signal from passing through without PEC wall. That is, it has a virtual PEC wall.



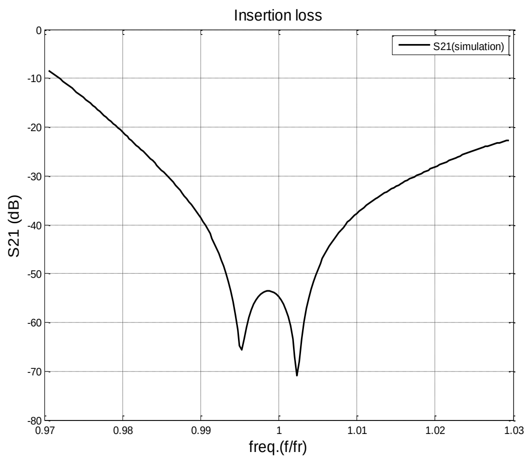
(a) 3D cut view



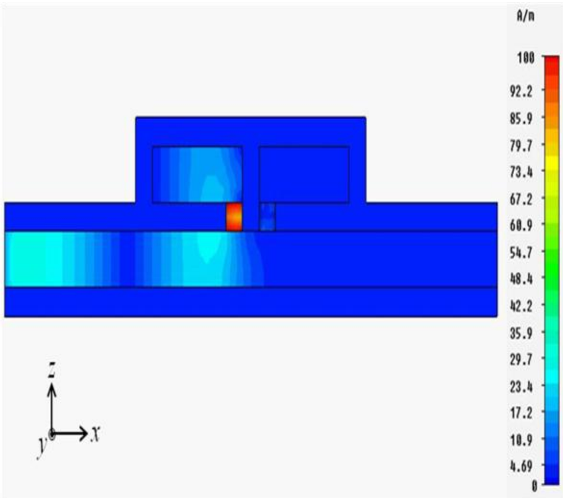
(b) Side view

Figure 1: Geometry of the proposed model

In order to verify how well this structure works, the folded waveguide is designed by CST. Design parameters in Fig.1 (b) are $l = 0.31\lambda$, $h = 0.11\lambda$. Waveguide width 0.68λ, slot width 0.05λ, and slot length 0.58λ are applied, respectively.



(a) Insertion loss



(b) Current flow

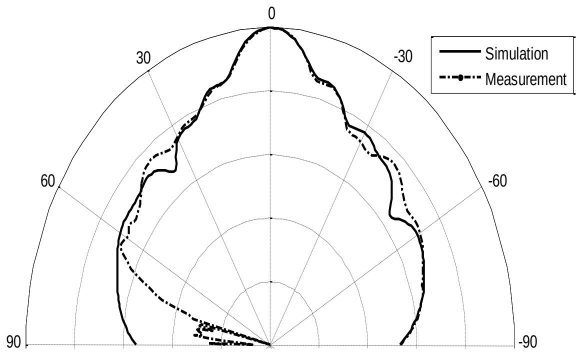
Figure 2: CST Simulation results

As shown in Fig. 2 (a), the signal below -35dB in hundreds MHz band can be considered as almost isolated. Also, Fig. 2(b) graphically indicates most energy propagating toward +x is coupled through slots and does not flow beyond x=0.

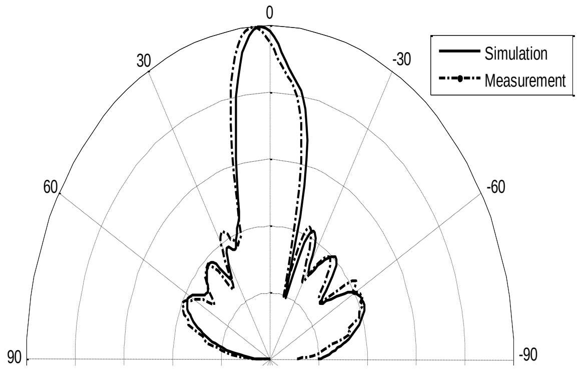
3. Measured Results

The new folded waveguide is applied to an actual monopulse waveguide slot-array antenna based on the design theory [4]. In the antenna using the new folded waveguide, what must be taken into account the most are sum, azimuth difference, and elevation difference pattern. Because two folded waveguides are connected structurally, the signal would propagate beyond x=0 in Fig. 1(b) if it is not effectively isolated in the antenna.

Fig. 3 and Fig. 4 represent radiation patterns of only one quadrant and total four quadrants of the antenna, respectively. It measured in a 15(W) x 6.5(L) x 7(H) m^3 anechoic chamber.

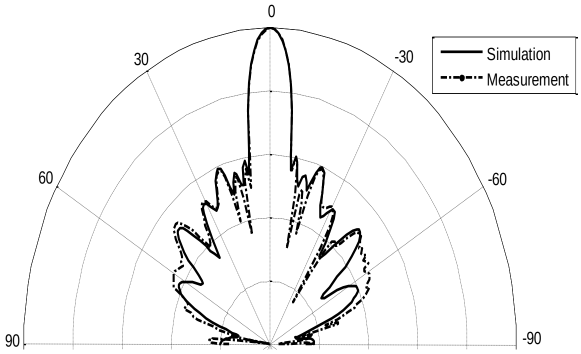


(a) Azimuth pattern

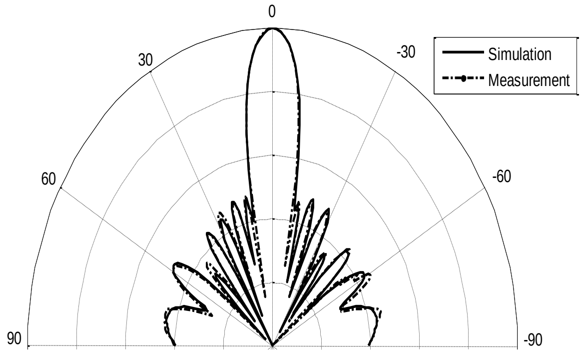


(b) Elevation pattern

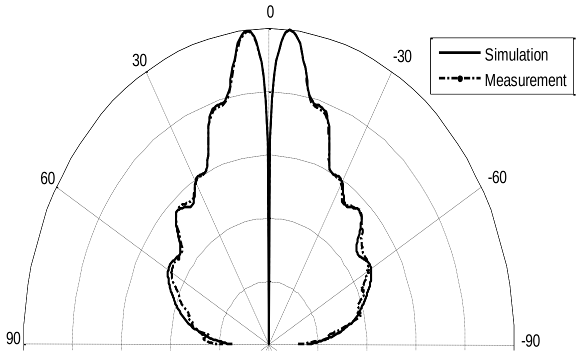
Figure 3: Patterns of 1st quadrant



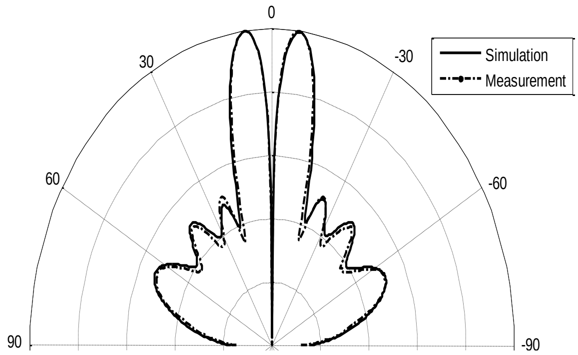
(a) Azimuth sum pattern



(b) Elevation sum pattern



(c) Azimuth difference pattern



(d) Elevation difference pattern

Figure 4: Total patterns of the four quadrants antenna

Fig. 3 shows each pattern of each quadrant has similar pattern and there is a good agreement between simulation data and measured data. Fig. 4 shows radiation patterns of sum and difference pattern. As it is presented in Fig. 4 (c)(d), the antenna with new folded waveguide has enough null depths, the same as a conventional monopulse antenna has.

4. Conclusion

The new folded waveguides for a monopulse waveguide slot-array antenna have been presented. The antenna using the new folded waveguide is simulated and measured. It has the good sum pattern and enough null depths in difference patterns like a conventional monopulse antenna although there is no PEC wall for the electrical isolation. The proposed structure is more cost-effective for the fabrication and also gives an easy way to remove a filler metal remaining inside waveguide after dip brazing.

References

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