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Measurement of a microstrip antenna array fed by transverse slots on a broad wall of the rectangular waveguide with standing-wave excitation for linear polarization parallel to the axis

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***Abstract* - This paper presents measurement of a microstrip antenna array fed by transverse slots on a broad wall of the rectangular waveguide with standing wave excitation for linear polarization parallel to the axis. A series-fed two-element microstrip antenna array on a dielectric substrate excited by a transverses slot of the waveguide is used as an element of the proposed array for grating lobe suppression due to the transverse slots. In this paper, a prototype array consisting of six microstrip antennas fed by three transverse slots on the broad wall of the rectangular waveguide with standing-wave excitation is designed and fabricated. The measured results are agreed with the simulated ones obtained by HFSS. The measured radiation pattern reveals that grading lobes due to the transverse slots are well reduced by the proposed array. Validity of the design of the proposed array is confirmed by the measurement.**

***Index Terms* — Waveguide slot array, Microstrip patch antenna, Planar antenna, Transverse slot array, Grating lobe suppression.**

I. INTRODUCTION

Waveguide slot arrays are commonly used for various purposes such as radars and communication systems [1]. A longitudinal slot array on a broad wall of the rectangular waveguide is one of the typical designs for linear polarization perpendicular to the waveguide axis. In order to design a slot array on the broad wall of the waveguide for linear polarization parallel to the axis, transverse slots are arranged on the broad wall of the waveguide at a spacing of approximately one guided wavelength for in-phase excitation. However it results in appearance of grating lobes because the guided wavelength of the waveguide is usually larger than that in free space. Suppression of grating lobes always becomes a problem for the transverse slot array. In order to shorten the slot spacing, a dielectric-filled waveguide or slow wave structures in a waveguide are utilized for the transverse slot arrays [2]. Another solution to reduce the guided wavelength is to use a ridged waveguide. T-shaped slot array arranged on the ridged waveguide for linear polarization parallel to the axis is reported [3].

The authors have proposed a novel planar array structure on a broad wall of the waveguide for linear polarization parallel to the axis [4]-[8]. A two-element series-fed microstrip antenna (MSA) array on a dielectric substrate, which is excited by a transverse slot on the broad wall of the waveguide, is used as an element of the proposed array. A design example of the three-element array with standing wave excitation is presented with HFSS simulation [9]. In this paper, a prototype array consisting of six MSAs fed by three transverse slots on the broad wall of the rectangular waveguide with standing-wave excitation is fabricated and tested.

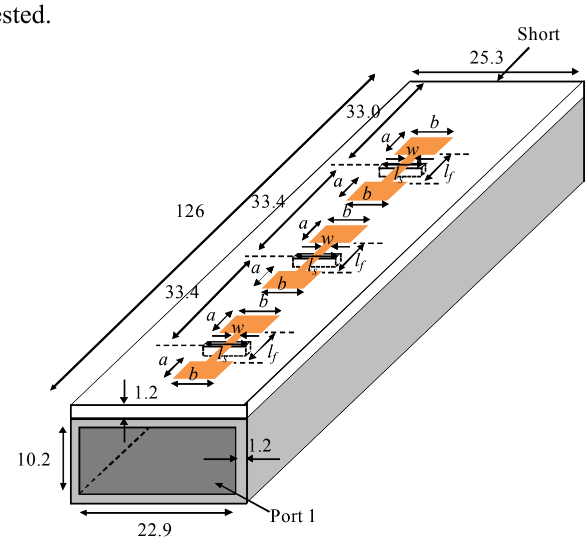


Fig. 1. Structure and dimensions of the prototype microstrip antenna array fed by transverse slots on a broad wall of the rectangular waveguide for linear polarization parallel to the axis.

II. STRUCTURE OF THE PROPOSED ARRAY

Fig. 1 presents a configuration of the proposed microstrip antenna array. Microstrip antennas (MSAs) on a dielectric substrate are placed on the broad wall with a transverse slot array. Two patches are connected by a microstrip line and operate as a series-fed MSA array. The two-element series-fed MSA array excited by one transverse slot forms an element of the array. For example, when the relative dielectric constant of the substrate is set to 2.6, the spacing of the two patches is approximately 0.62 wavelengths in free space, which is corresponding to around a half of the guided wavelength in the waveguide. Thus, the grating lobes of the transverse slot array can be eliminated. Polarization of the proposed array is parallel to the axis of the waveguide.

III. Measurement of the Prototype Three-Element Array with Standing-Wave Excitation

A three-element array with standing wave excitation as shown Fig. 1 is designed and tested. In this design, three elements consisting of six MSAs fed by three transverse slots with identical geometry are arranged at a spacing of one guided wavelength on the broad wall of the short-terminated waveguide. The design frequency is 11.2 GHz. The parameters of the elements are tuned to l_s = 8.6 mm, l_f= 15.2 mm, w = 1.0 mm, a = 8.4 mm, and b = 13.2 mm. Fig. 2 presents the simulated and measured frequency response of reflection (S_{11}) of the prototype array, where the simulated result is obtained with HFSS. Good impedance matching is obtained at 11.2 GHz. Fig. 3 presents the simulated and measured radiation patterns of the array at 11.2 GHz. A sharp main beam in E-plane and a broad beam in H-plane are observed. Good agreement between the simulated and measured results is observed in the both E- and H-planes. The grating lobes at around 50 deg. directions in the E-plane pattern are suppressed below around –16 dB. Fig. 4 presents the simulated and measured gain of the array. The measured gain at the design frequency is 14.1 dBi.

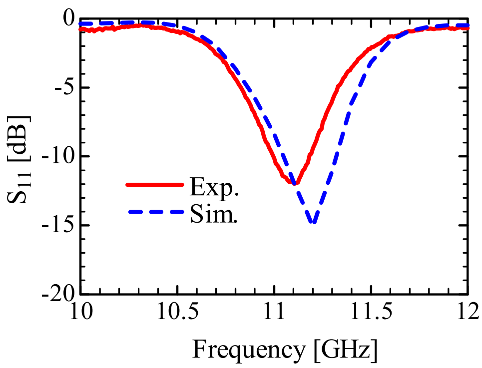
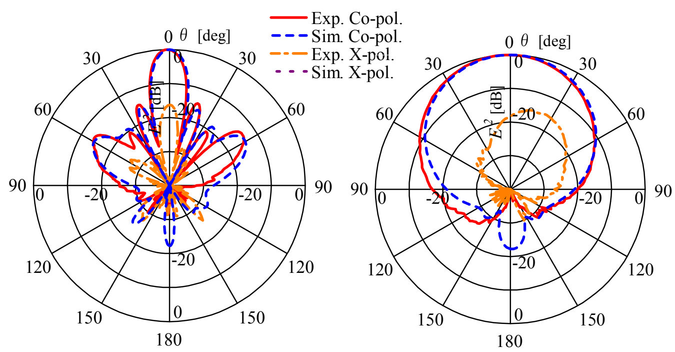


Fig. 2. Reflection characteristics.



(a) E-pl. (b) H-pl.

Fig. 3. Radiation patterns.

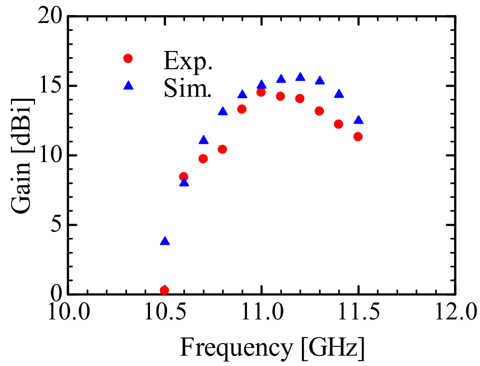


Fig. 4. Gain.

IV. Conclusion

A microstrip antenna array fed by transverse slots on a broad wall of the rectangular waveguide with standing wave excitation for linear polarization parallel to the axis is designed and tested. The prototype array consisting of six MSAs fed by three transverse slots on the broad wall of the rectangular waveguide is fabricated. The measured results are agreed with the simulated ones obtained by HFSS. Good radiation pattern with the measured grading lobes below –16 dB is measured. Validity of the design of the proposed array is confirmed by the measurement.

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