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Continuously Tapered Sinusoidally Modulated Reactance Surface Antenna

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***Abstract* – Continuously tapered sinusoidally modulated reactance surface (SMRS) antenna is proposed. The unit cells of the proposed SMRS antenna are slightly perturbed cell by cell to achieve the desired continuous aperture distribution while keeping the unit period of the sinusoidally modulated reactance surface same. We have compared our proposed continuously tapered SMRS antenna with discretely tapered case and the simulation result show lower sidelobe level of the radiation pattern of the antenna while keeping other characteristics almost same. The designed antenna radiates at 35° off broadside at 10 GHz and 17.6 dBi of simulated gain was obtained with normalized sidelobe level of -13 dB.**

***Index Terms* — Leaky-wave antennas, sinusoidally-modulated reactance surface antenna, aperture tapering, sidelobe level.**

1. Introduction

The initial research on the guidance and radiation properties of sinusoidally-modulated reactance surface (SMRS) [1] provided a possibility of utilizing this concept to the leaky wave antennas. The design procedure and radiation characteristic of the SMRS antenna were researched in the previous paper [2] and the salient feature of this SMRS antenna is the independent control of leakage constant and phase constant within an allowable small range of reactance modulation value.

About the radiation pattern of the SMRS antennas, a uniform modulation of reactance surface was applied for the verification of the general radiation characteristic of the SMRS antenna [2]. However, aperture tapering technique have been widely used for various antenna types to obtain the desired radiation beam pattern [3]-[4]. Also, there was a research on the aperture tapering of the quasi-uniform leaky wave antennas for the desired beam pattern synthesis and radiation pattern calculation [5].

In this paper, we applied a continuous aperture tapering technique to the SMRS antenna utilizing the independent control of leakage and phase constant of the unit cell. Slight perturbation was applied to the gaps of the unit cells for the continuous aperture tapering of the SMRS antenna. Matching characteristic and radiation pattern result of the proposed SMRS antenna is compared with the discretely tapered case.

2. Continuously Tapered SMRS Antenna

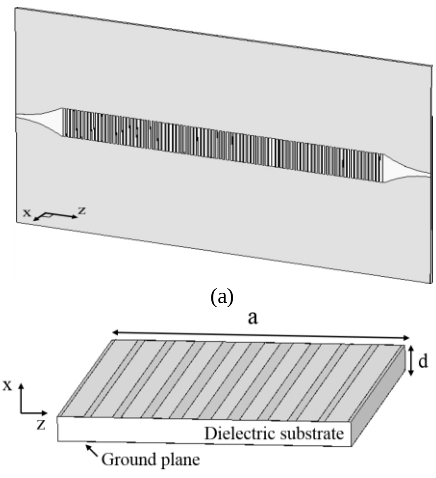

Fig. 1. Proposed 3D model of tapered SMRS antenna (a) and its unit period configuration (b).

The SMRS antenna is composed of sinusoidal reactance surface along the direction of propagation and its reactance can be expressed with the equation below

$$\eta_{surf}(z) = j\eta_0 X'\left[1 + M\cos\left(\frac{2\pi z}{a}\right)\right]. \qquad (1)$$

Where M is the modulation factor, a is the period of the sinusoidal function, and X' is the average surface reactance divided by the free-space wave impedance($X' = X/\eta_0$). Our proposed continuously tapered SMRS antenna and its unit period configuration are shown in Fig.1.

From the above equation, the parameter X' determines radiating beam angle (phase constant) and M controls beamwidth (leakage constant) of the SMRS antenna by varying the gaps between the strips so as to control the surface reactance of the SMRS antenna.

We have designed continuously tapered SMRS antenna and overall length of the antenna is 270 mm long and compared with the discretely tapered SMRS antenna case composed of nine-tapered unit periods with same overall antenna length with continuously tapered case. The unit period length of discretely tapered SMRS is 30 mm and composed of ten strips and nine gaps between the strips so the length of the unit cell is 3 mm. The calculated aperture illumination of both antenna cases are plotted in Fig.2 and compared with ideal cosine distribution. The antenna is

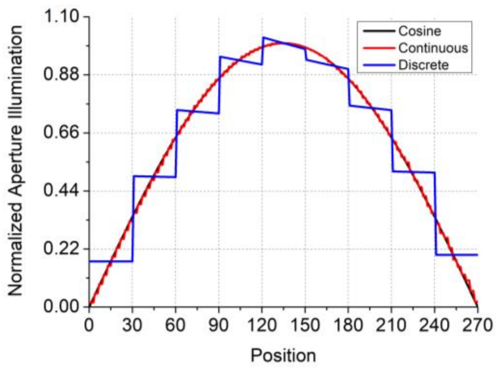

Fig. 2. Normalized aperture illumination of designed antennas and ideal cosine distribution.

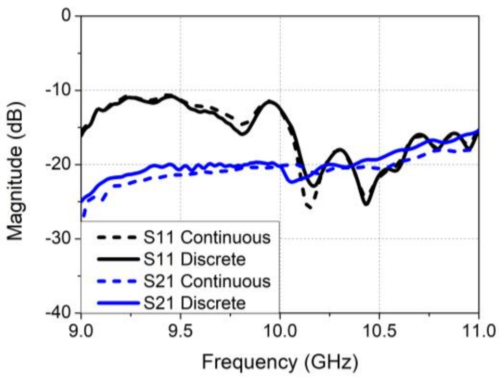

Fig. 3. Return loss (Black) and insertion loss (Blue) of continuously and discretely tapered SMRS antennas.

designed to radiate at 35° off broadside with the center frequency of 10 GHz.

Proposed continuously tapered SMRS antenna has small perturbation cell by cell so that can mimic the ideal cosine distribution with the continuum of ninety-exponentially decaying functions of radiating leaky waves. In contrast, discrete tapered case shows the aperture illumination of nine discrete exponentially decaying functions controlled by period by period with different surface modulation factors M.

3. Simulation Results

Fig.3 shows the simulated results of return loss and insertion loss of continuously tapered and discretely tapered SMRS antennas whose EM model is as shown in Fig. 1 (a). The results of continuously tapered case show quite similar characteristic when compared with discretely tapered case and keeps good matching within the simulated band (9 to 11 GHz).

Fig.4 shows the simulated radiation pattern of the continuously and discretely tapered SMRS antennas. The result of continuously tapered case shows almost same main beam direction and beamwidth with the discretely tapered case. However, the overall sidelobe level of continuously tapered case is lower than that of the discretely tapered case.

We have obtained about 17.6 dBi gain for both tapered case and same level of maximum sidelobe at -23° which is due to the radiation of -2nd floquet mode from the periodic structure of the SMRS antenna.

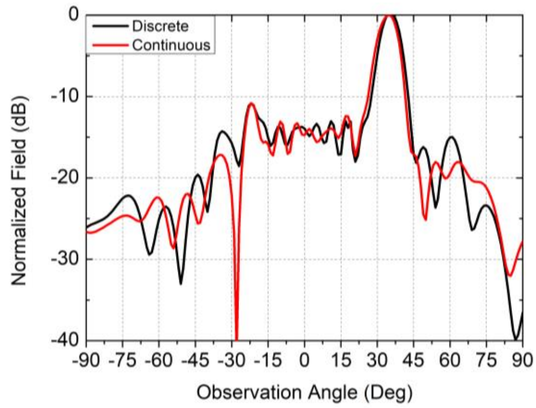

Fig. 4. Radiation patterns of continuously and discretely tapered SMRS antennas.

4. Conclusion

We proposed a continuously tapered SMRS antenna which is slightly perturbed by varying the gaps of the unit cells from the design of nine-tapered SMRS antenna. Perturbed unit cells of continuously tapered SMRS antenna does not affect the periodicity so keeps the same main beam direction with discretely tapered case. Also, matching characteristic of the continuously tapered SMRS antenna was almost same with discretely tapered case. However, the overall sidelobe level was improved when compared to discretely tapered case due to the aperture illumination of continuously tapered case is more similar to the ideal cosine distribution.

Acknowledgment

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