Design and Analysis of Wideband Microstrip Reflectarray Unit cell

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Abstract: Design of a wideband single layer reflectarray antenna is presented in this paper. The two different radiating elements is proposed, to achieve wider bandwidth at X band 9.6G Hz. Elements are synthesized the design having element spacing of 0.6λ reflectarray aperture, showing stimulated bandwidth of 23.2%.

***IndexTerms* - Wideband, Microstrip antenna, resonance element.**

I. Introduction

For long distance communication, high gain antenna is widely used in communication satellite, where high gain antenna includes reflector, lens, and antenna array. To fulfill this demand parabolic reflector antenna and antenna array used for decay. Due to demerits of reflector like bulky size, minimum beam scanning capability, high feed loss, cross polarization. Reflectarray antenna is an alternative to both antennas, which provide high gain, higher aperture efficiency, lightweight, planar surface, element phase adjustment and beam scanning capability [1]. There are two demerits of the reflect array antenna is its bandwidth is limited due to narrow bandwidth of the element and spatial phase delay is difference between path length from feed to each element [2]. Reflectarray antenna includes radiating element on planar surface that is incident by feed antenna and geometric optics from feed antenna to radiating surface. The basic principal of reflect array antenna is the feed antenna ray is incident on radiating element with certain angle that are design to reradiate and scatter the incident angle with phase shift that are require to form planar phase front in the far field [3] as shown in Fig 1. The radiating element consist of microstrip patches, dipole or ring [4] [5]. Phase shift distribution carried out using these radiating elements. The planar surface contains infinite array of patch that can be variable patch size [2] [6], variable angular rotation [7] and variable length phase delay line [8] [9]. The element bandwidth enhanced by using multilayer structure [10], aperture coupled patches [11] or using large linear phase range [12]. The element is design to measure reflection phase shift used to analysis variable size sizes of individual element to see phase difference of the incident wave of the feed, which reflect from planar surface to generate beam pattern in desired direction. The reflection phase characteristic depend upon slope and phase range.

The aim of this paper is to analysis design of single layer with variable size of square ring [14] and 45˚ tilted patch elements [13] is designed to improve bandwidth of single layer microstrip reflectarray. By adjusting size of these element and inserting layer of glue and foam between substrate and ground, increase phase range above 360˚ to reduce reflection phase error for fabrication accuracy. The advantage of these elements are to examine reflectarray operating at X band.

II. Unit Cell Design

A single-layer microstrip element introduced to enhance bandwidth of reflectarray operation within X band with central frequency 9.6 GHz. The element consists of a square ring and diamond shape patch, as shown in Fig. 2 (a). The scattering characteristics of unit cell analysis and optimization done in Ansys designer software by using plane wave excitation and infinite periodic approach. The element spacing is A= 18mm, which is equivalent to 0.6 wavelengths at 9.6 GHz. The stackup layer of array of unit cell element is assume to be printed on dielectric substrate with thickness h= 0.245mm, relative permittivity ε_r= 2.7. The substrate is mounted on glue layer with thickness g=56 μm and foam with f= 5 mm thickness. Glue layer is between foam and ground plane. The diamond shape patch is surrounded by square ring its length and width denoted by L and w respectively, length of square patch is Ls. The relation between parameter is analysis by given equation in [13]. Where width of square ring w= 0.486 mm, L and Ls are varying from 3.75 mm to 18 mm.

As all elements, sizes are varying with incident plane wave on patch at 8.68-11 GHz, and each element have reflection phase as per elements size and position. To remunerate different phases, the reflection phase curve should cover a phase range of 360˚, and curve should be linearly smooth in order to reduce the fabrication sensitivity [3]. Fig. 3 shows the phase curves versus patch size of unit cells at 9.6 GHz. Because of the resonance from the inner patch and the outer square ring, the proposed unit cell provides a phase range of 435˚.

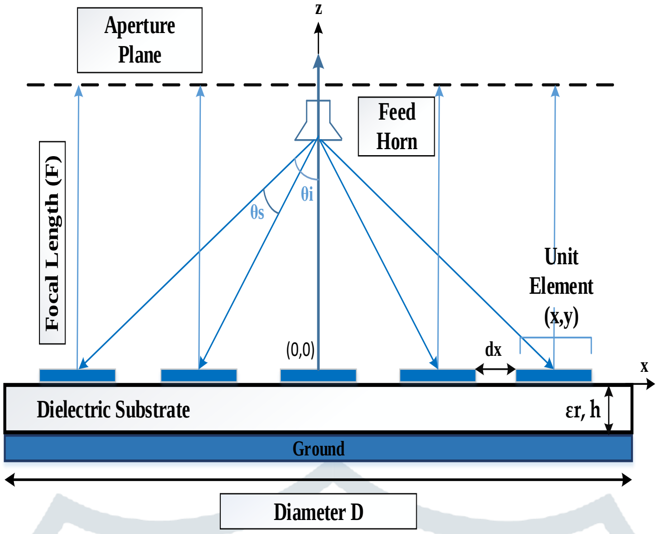
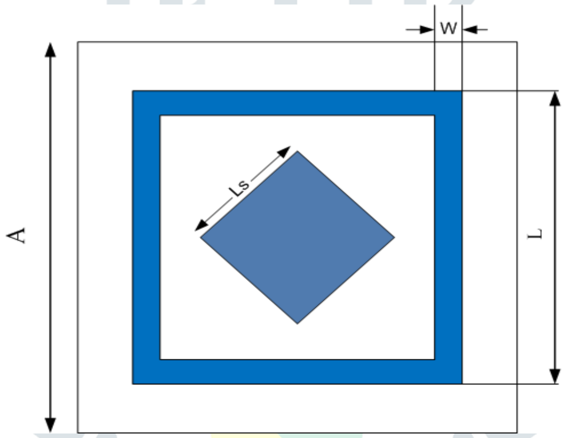
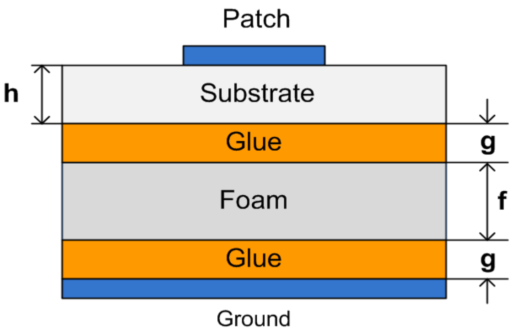


Fig 1. Schematic diagram of reflect array antenna

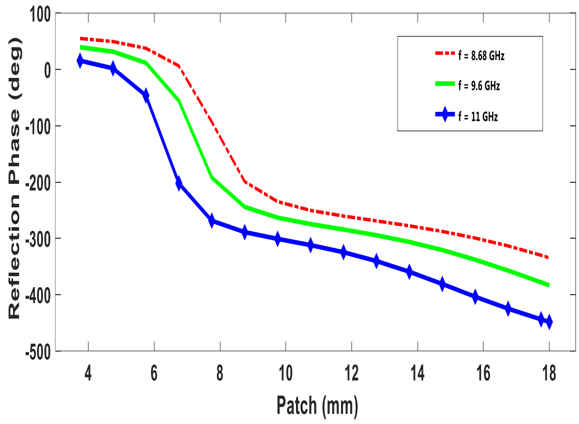


(a)

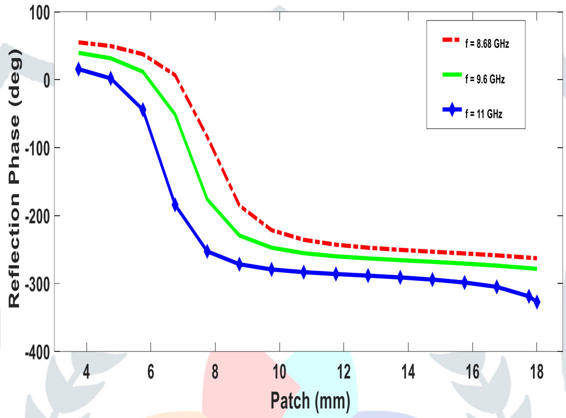


(b)

Fig 2. (a) Proposed Unit element cell, (b) Stackup layer of above unit cell



(a)



(b)

Fig 3. Phase reflection coefficient v/s patch size at 8.68-11GHz. (a) Proposed unit cell (b) Square ring

The phase ranges of proposed unit and square rings and diamond shape patch are respectively 400˚and 350˚ respectively. The reflectarray antenna bandwidth can examined by reflection phase curve having more than 7% of reflection.

As observed in Fig 3. Phase range is reduce from about 320˚ to 400˚, while comparing the phase range obtained from Fig 3. That the proposed cell phase range increased by approx. 70˚ than double square ring phase range. This difference of phase range of proposed cell and outer square ring is as width increases the slope of the phase response decreases [14]. From Fig 3. (a) Proposed structure incident plane wave (θ= 0˚), having good bandwidth 2.32 GHz relatively 23.2%.

III. CONCLUSION

The design and analysis of proposed unit cell at X-band single-layer reflect array including single resonance that formed by array of elements in the form of square rings and diamond shape patch has been presented. The element has more than 360˚ linear phase range, that define unit cell has less phase error. The simulated performance of the proposed unit cell observe that this type of geometries may features good radiation pattern and increased element bandwidth.

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