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Analysis of a New Design Structure For Reflectarray Antennas

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Abstract— The key factor in the designing of reflectarray antennas is the determination of the phase range of each element constituting the antenna array, this parameters is improved by introducing slots in the radiating element, and by adjusted their dimensions. A novel structure of radiating antenna is developed whose geometry is Bowtie. The reflection coefficient phase is obtained by the unit cell waveguide approach under the CST Microwave Studio.

Keywords- reflectarray antenna, waveguide approach, Bowtie antenna, reflection coefficient phase.

I. INTRODUCTION

An antenna similar to the parabolic antenna has been developed using microstrip technology, called array antenna reflector or printed reflectarray. Early studies of the network reflector were those of Berry and al [1], and the idea has been extended to microstrip antennas by Munson [2]. Comparing with the parabolic reflector, this new configuration of antenna array allows the design of printed antennas without power system with a high gain and low cost. The excitement is not direct but is by illumination through a primary source. Their contribution to the radiation pattern is by thought. Their use has recently been extended to the field of satellite communications and radar applications. The reflector array possesses the advantage of being flat, thin and conformable. This allows incorporating the walls of a satellite [3].

It can also be folded, unfolded the same way as solar panels, making it easy to transport. Also, compared to phased arrays, reflectarray eliminates the complexity and power losses in the network and allows a high yield. Such an antenna will be an attractive option for radar applications, mobile and satellite communications.

A. DESCRIPTION OF THE PRINTED REFLECTOR ARRAY ANTENNAS

An array antenna reflector or reflectarray, as its name implies, a combination between the concept of antenna reflectors and the antenna networks. A reflector array consists of a primary source that illuminates the network printing. The latter, in its simplest form, is simply a planar array of patches printed on a substrate coated therewith, all on a ground plane as shown in Fig. 1.

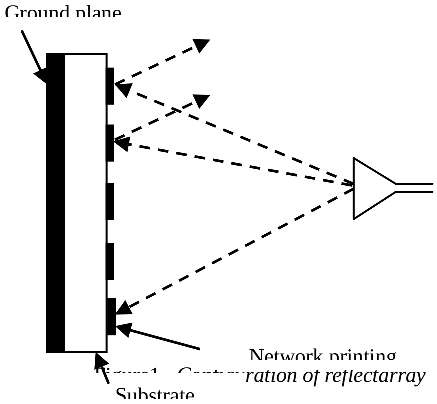

Figure1. Configuration of reflectarray

The reflector array can be considered an infinite periodic network, composed of identical cells microstrip elements, illuminated by plane wave.

The incident field is defined as a plane wave from (1):

$$\vec{E}^{inc} = \vec{E}_0.\exp(j\vec{k}.\vec{r}) \quad (1)$$

Different electric fields can arise over the diagram of Fig. 2:

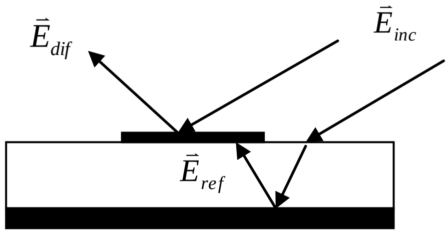

Figure2. *Electric fields for a period of infinite network*

B. Advantage and disadvantage of reflactarray

The two technologies used in the design of reflector arrays each have their advantages and disadvantages. For array antennas, the major advantage is the ability to control the weight amplitude and phase of each element of the network, and help control the direction of the emitted wave and the beam shape. And more, an electronic control of each network element allows very fast scanning speeds. The disadvantage of this technology is still in the complexity of the supply circuit and the resulting losses. In the case of reflector antennas, the problem of the supply system is solved by using a single primary source illuminating the reflector. In return, there are technological difficulties such as the weight, and mechanical misalignment of the antenna [4].

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01 Dec. 2013

Reflector antenna system combines the advantages of both technologies cited above. Thus, it operates with a single primary source that illuminates the reflector plane (which prevents the establishment of a supply circuit complex and dissipative). Given that the radiating elements of the network, called cells phase shifts, re-radiate in phase, the energy emitted by the source in the desired direction. Therefore, the properties of the wave re-emitted will be controlled by law phase generated by the network. This phase law corresponds to the phase synthesized by each cell. Thus, the re-radiation of the transmitted wave may undergo significant depointing without playing on the position of the reflector. This law can also be used to generate a radiation pattern of the antenna according to a given template. It may be noted that the size of the network will set the maximum directivity. The network is not selected, meanwhile, according to grating lobes and misalignment to affect the wave re-emitted. It remains after taking into account the constraints imposed by the structures of the antenna, to define the primary source.

II. SIMULATION PHASE REFLECTED

The simulated phase reflected was done using the technique of waveguide. Law corresponding phase is plotted by adjusting the geometrical parameters of the radiating element in an environment without interaction of neighboring cells (without coupling effect).

A. *Wave guide approach*

The excitation of the radiating element by a primary source is represented by the model of the waveguide where the walls of the guide are defined by walls and electric magnetic (fig 3), the desired operating frequency. The extent of the reflection coefficient S11 at the input of the waveguide allows us to determine the phase of the reflected wave.

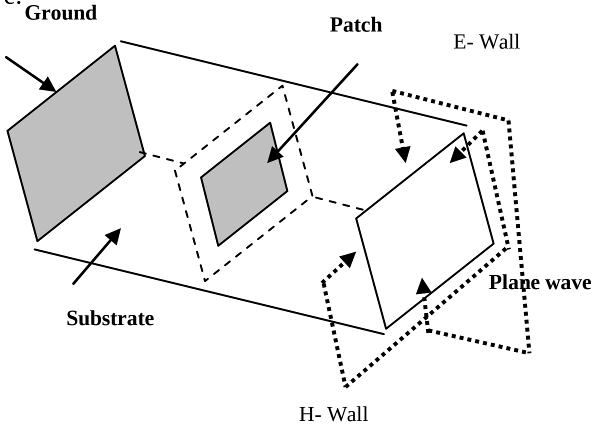

Figure3. Structure of waveguide approach

B. *Design of unit cell*

We propose in this article a new antenna structure, whose geometry is Bowtie. It is a very special antenna that enables with its shape to achieve a phase control of the reflected wave.

The unit cell of reflectarray is designed at X-band frequency of 11GHz, and the analysis is implemented using available full-wave simulation tool Computer Simulation Technology Microwave Studio (CST MWS).

The unit cell of Bowtie antenna has a dielectric of permittivity 3.54 and thickness of 1.524 mm, with tan δ of 0.0018, disposed on a copper ground plane with thickness of 0.035 mm, Fig. 4 shows the dimensions of this unit cell.

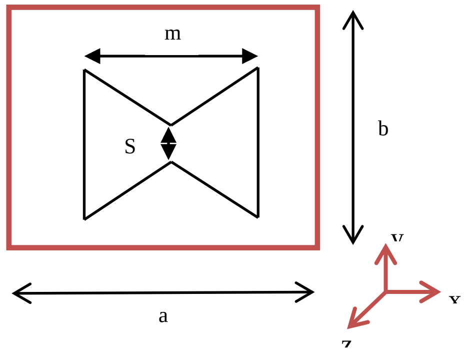

Figure4. Dimensions of Bowtie antenna
(m = 5.41mm, η = 0.5, a = 11.43mm, b = 10.16mm)

$$S = \eta * \frac{m}{2} \qquad 0 < \eta < 1$$

C. *Reflection phase simulation of unit cell*

In the simulation, the unit cell is excited using TEM mode, we use different approach for the designing of Bowtie antenna and in each approach, m is varied in percentage.

1st approach:

The first approach of our study is the analysis of phase depending on the variation of the dimensions of the initial Bowtie antenna as shown in fig.5, and the reflection phase is obtained at fig.6.

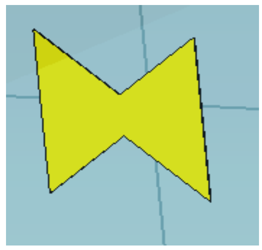

Figure5. View of Bowtie antenna in CST MWS

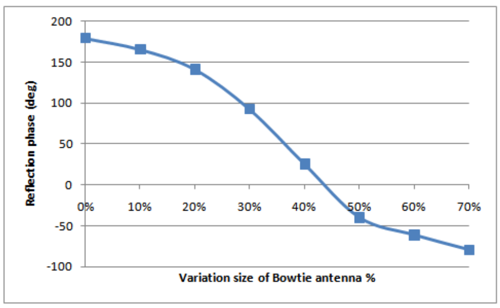

Figure6. Reflection phase of Bowtie antenna at 11GHz

From Fig.6, we note that the range of reflection phase of

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Bowtie antenna is 251.1°, and it's obtained from variation of 0% (the size initial of Bowtie) to 70%.

2nd approach

In this approach, we add a slot in the initial Bowtie antenna (Fig. 7), the range of phase is important relative Bowtie without slot and its 349.19° (Fig.8). The phase range is obtained from 0% to 44%.

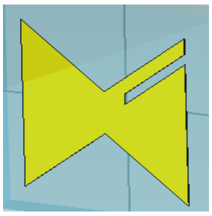

Figure7. Bowtie antenna with slot

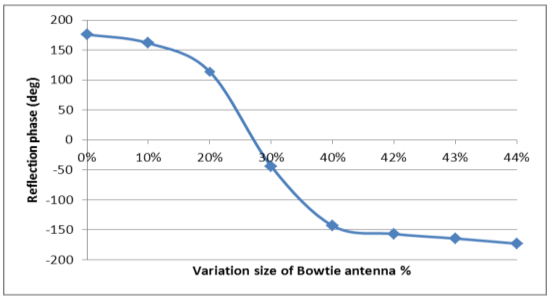

Figure8.Reflection phase of Bowtie antenna with one slot

3nd approach

In this approach we add a new symetrical slot to the first slot relative to the y axis (see Fig.9). The phase range is obtained at a variation of 348.78° from 0% to 57% (Fig.10).

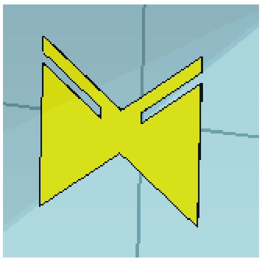

Figure9. Bowtie antenna with two symmetrical slots versus y axis

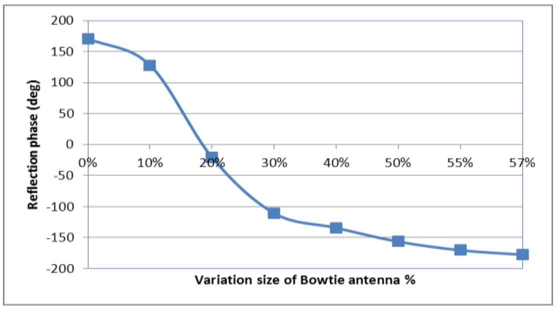

Figure 10.Reflection phase of Bowtie antenna with two slot

4th approach

The two slots are placed in the same diagonal (Fig.11), the phase range is obtained at variation of 350,15° from 0% to 59% (Fig.12).

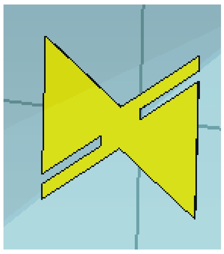

Figure11.Bowtie antenna with two diagonal slots

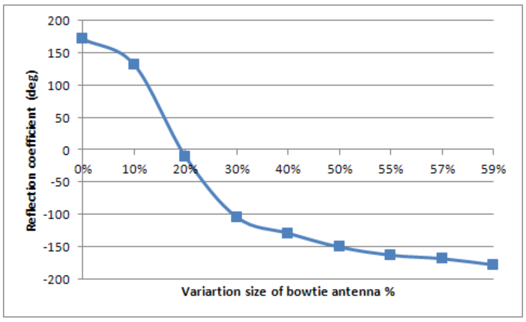

Figure 12.Reflection phase of Bowtie antenna with two diagonal slots

5th approach

In this approach the tow slots are parallels to y axis (Fig.13). The result of simulation is obtained at Fig.14; the range of phase is about 351.92°, and the variation of size of patch antenna is from 0% to 42%, and it's narrower than the other patchs.

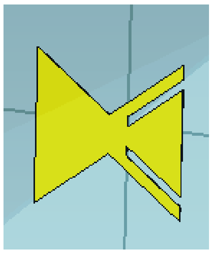

Figure13. Bowtie antenna with two slots parallel to y axis

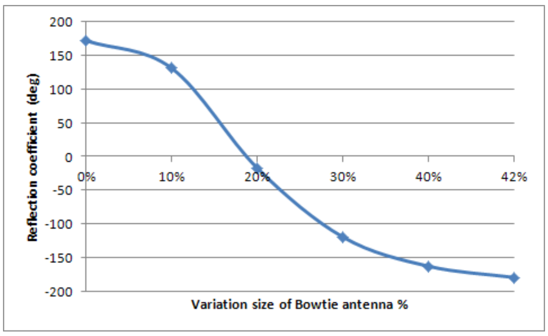

Figure14.Reflection phase of Bowtie with two slots

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01 Dec. 2013

The comparaison between the differents approachs is presented in table 1.

Differents approach	Phase range	Range variation of dimansion of Bowtie antenna
1st approach	251.1°	0%- 70%
2nd approach	349.19°	0%- 44%
3rd approach	348.78	0% -57%
4th approach	350,15°	0%-59%
5th approach	351.92°	0%-42%

Table 1. The comparaison between the differents approachs

II. CONCLUSION

A new shape of reflectarray antenna was analysis and introduced. The initial antenna is based on the Bowtie geometry. An introduction of slot in patch improves the range of the reflected phase, and reduces the variation of size range. This new patch antenna can be used to miniaturize the size of the reflectarray antennas.

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