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Design and Implementation of Wideband Antenna for Satellite Communication

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ABSTRACT: A Wideband antenna using Meta-surface structure C-band satellite communication application is proposed in these letter. The proposed antenna consists of corner truncated square structure 3x3 array pattern, aperture coupled feed, used for these proposed structure to enhancement of bandwidth and better gain results. The simulated results shows that -10 dB impedance bandwidth of the proposed antenna 40.39% from 4.8617 to 7.3224 GHz. The proposed antenna overall dimension is 27.5x27.5x4mm^3, performs well and achieves good directivity and gain as 6.38 dB. This antenna designed on Computer simulation technology (CST) microwave studio software, impedance bandwidth, VSWR, return losses and gain are observed and experimentally studied. Details of simulated results are presented and discussed.

KEYWORDS: Metasurface, wideband antenna, Satellite communication,

I. INTRODUCTION

The microstrip antennas are low-profile, low weight, ease of fabrication, conformable to planar and non-planar surfaces and mechanically robust. In the last 40 years, the microstrip antenna has been developed for many communication systems such as radars, sensors, wireless, satellite, broadcasting, ultra-wideband, radio frequency identifications (RFIDs), reader devices etc. Basically a micro strip antenna consists of a planar radiating element of different geometrical shape on one side of a dielectric substrate material and a ground plane on the other. Generally the preferred geometries are rectangular and circular. There are different types of feeding techniques are available to connect power to a micro strip antenna. These types include Micro strip feed, Co-axial feed, Aperture coupling feed and Proximity coupling feed Each one of these types has its own advantage and disadvantages that makes it suitable for certain applications

Metamaterials are novel synthetic materials engineered to achieve unique properties not normally found in nature. Metamaterials are recently developed artificial materials, and having a properties of negative permittivity, permeability and negative refraction index. In Greek Meta means above/after/beyond/superior,Metamaterials are named so as these exhibit properties beyond the properties of naturally available materials. It was developed in 1967 by Russian theorist Victor Veselago. These are artificial metallic structures that have dimensions much smaller than the wavelength of incident radiation.Metamaterial is not a special type of material, if an array of structures of any metal will be able to change the electric and magnetic property of the wave passing through it and leads to negative permittivity and refractive index simultaneously, that metallic structure can be called as metamaterial.

Electromagnetic Metamaterials are artificially structured materials and are designed to interact with and control electromagnetic waves. Electromagnetic waves might be any type of wave in the electromagnetic spectrum. Most of us are familiar with light waves in the visible spectrum, which occupy a small portion of the electromagnetic spectrum. Visible light waves have wavelengths from 400 to 700 nanometers (a nanometer is one-billionth of a meter), yet electromagnetic waves can have wavelengths of thousands of kilometers to trillionths of a meter. Electromagnetic crystals are artificial periodical structures operating at frequencies where the wavelength is comparable with the characteristic period of the structure. In the optical frequency range, such structures are called photonic crystals. The inherent feature of such media is the existence of frequency bands inside which wave propagation is not allowed.These bands are called bandgaps, and therefore these crystals are sometimes also called electromagnetic bandgap (EBG) or photonic bandgap (PBG) structures.The bandgaps originate physically from the spatial resonances of the crystal and strongly depend on the direction of wave propagation. This means that electromagnetic crystals are media with spatial dispersion.

Electromagnetic metamaterials (MTMs) are broadly defined as artificial effectively homogeneous electromagnetic structures with unusual properties not readily available in nature. An effectively homogeneous structure is a structure whose structural average cell size p is much smaller than the guided wavelength λg. Therefore, this average cell size should be at least smaller than a quarter of wavelength, $p < \lambda g/4$.

The proposed antenna consists of two parts, i.e. a MS superstrate consists of 9 unit cells of rectangular patches arranged in a 3×3 array printed on a dielectric substrate, and a slot antenna with planar vertical slot embedded on the ground plane. These proposed antenna is compact and low-profile, the MS and the slot antenna are placed together in direct contact. CST Microwave Studio software was used to simulate the proposed antennas in order to compare their characteristics in terms of the reflection coefficient, gain, and bandwidth.

II DESIGN OF THE PROPOSED ANTENNA

The structure of the proposed low-profile wideband band antenna is shown in Fig. 1. It is composed of two parts: One is the 3×3 corner truncatedsquare patches MS array and the other is a planar slot coupling antenna with a vertical slot embedded on the ground plane. To integrate the metasurface superstrate with the slot coupling antenna, As shown in Fig.1, the MS parameters are as followsLength=8.5 mm, Width=8.5 mm, and gap=0.5 mm, between patches. While Feed length=20.75 mm, Feed width=1.86 mm, At the same time, FR4 ($\varepsilon r=4.3$, $\tan\delta=0.02$) is used as both MS substrate and antennafeed substrate. The MS substrate thickness is h=3 mm, while antenna substrate thickness is t=1 mm. The vertical slot with length=20 mm and width=2 mm is cut onto the ground plane for energy coupling between the feed-line and MS. The overall dimension of the proposedantenna is 27.5×27.5×4.0 mm^3, and the slot on the ground is vertically positioned with respect to the feed-line.

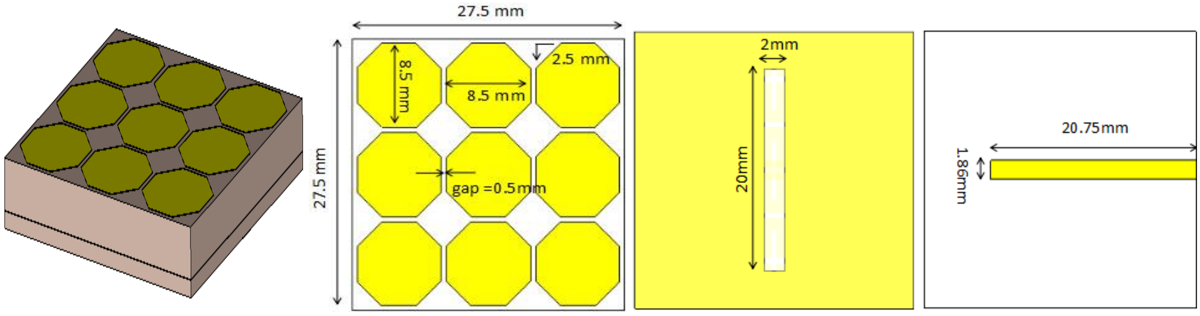

Fig. 1. 3D view, Top plane, Ground plane and Bottom plane

It is worth pointing out that the tilted slot is on the middle layer and the feed-line is on the bottom layer, which can adjust the impedance matching and implement more flexible. If the same arrangements as were arranged, in which the feed-line and the slot layers are switched and an SMA connector was used to feed to the feed-line through the ground plane and substrate of the slot, the antenna performances such as $|S_{11}|$, gain and axial ratio.

III. SIMULATED RESULTS

The proposed antenna is simulated by CST simulation software, simulated results as S_{11} are shown in Fig. 2. The measured impedance bandwidth ($|S_{11}| < -10$ dB) 39.6% is 2.4607 GHz, from 4.8617 to 7.3224 GHz. The aperture coupled feed is used for these proposed antenna, to optimize the impedance bandwidth, gain, and returnloss results. The bandwidth is measured at -10 dB points on either side of the peak emission. If these upper and lower points are represented by f_H and f_L, respectively, the fractional bandwidth and center frequency can be derived as, Bandwidth (BW) = $2(f_H-f_L)/(f_H+f_L)$, fc= $(f_H+f_L)/2$, where fc is center frequency.

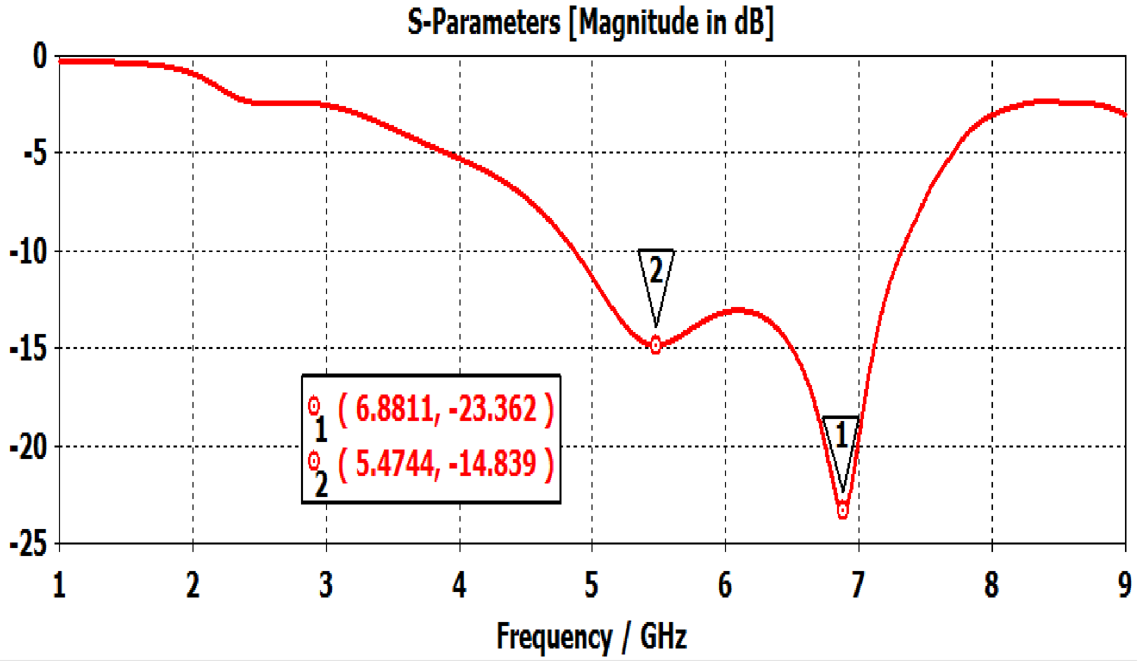

Fig. 2. S-parameters

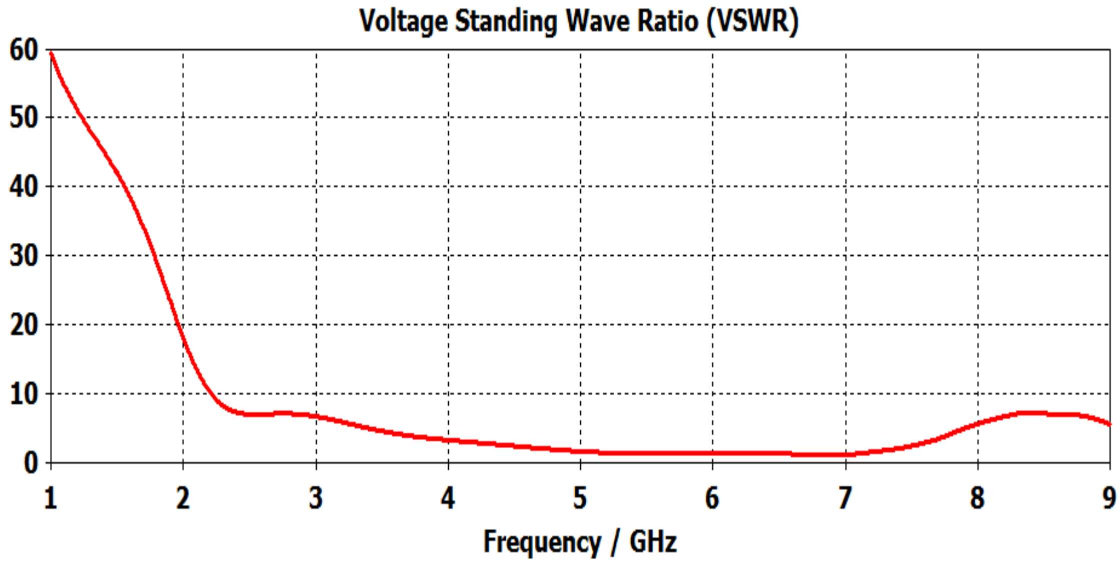

Fig. 3. VSWR

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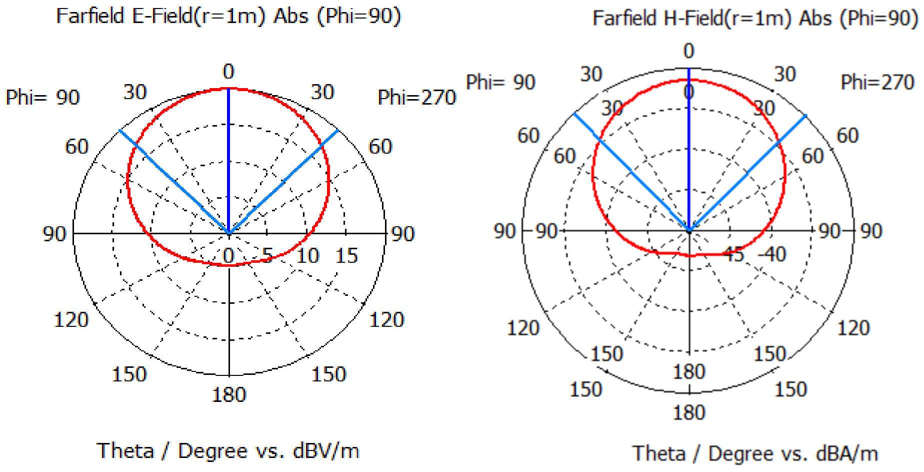


Fig. 4(a). E and H fields for Fr=5.4744 GHz

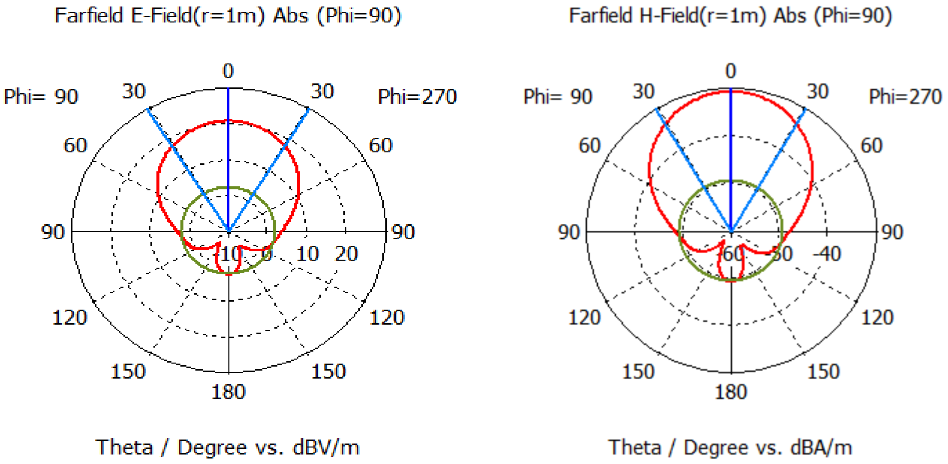
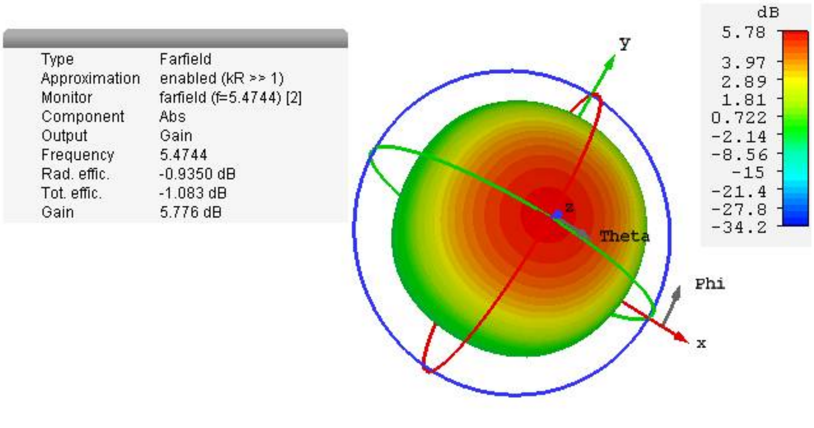
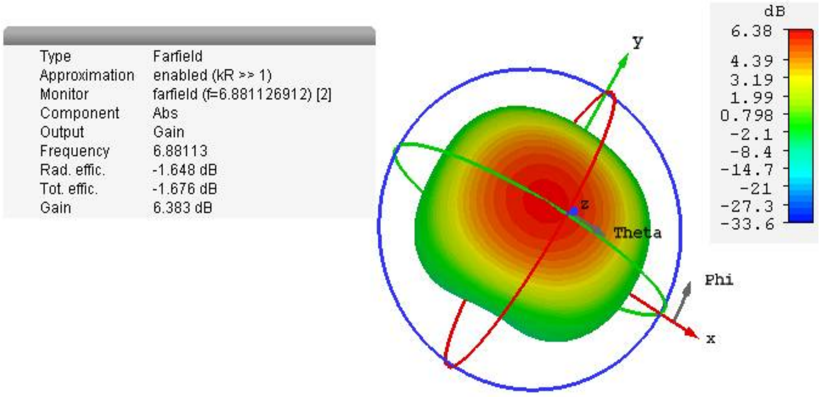


Fig. 4(b). E and H fields for Fr=6.8811 GHz



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=5.4744) [2]
Component	Abs
Output	Gain
Frequency	5.4744
Rad. effic.	-0.9350 dB
Tot. effic.	-1.083 dB
Gain	5.776 dB

Fig. 5(a). 3D Radiation pattern for Fr=5.4744 GHz



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=6.881126912) [2]
Component	Abs
Output	Gain
Frequency	6.88113
Rad. effic.	-1.648 dB
Tot. effic.	-1.676 dB
Gain	6.383 dB

Fig. 5(b). 3D Radiation pattern for Fr=6.8811 GHz

IV. CONCLUSION AND FUTURE WORK

A new low-profile wideband antenna using metasurface (MS) design for C-band satellite communication is introduced and investigated. Owing to the introduction of corner truncated square MS superstrate and a vertical slot cut onto the ground plane, The proposed antenna 3x3 array has a compact structure with a low-profile simulated results show that the -10 dB impedance bandwidth of the proposed antenna is 40.39% from 4.8617 to 7.3224 GHz, and with achieved gain of 6.38 dB and Directivity as 8.03 dBi.

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