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Design of Monopole Antenna using Frequency Selective Surface Layer

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ABSTRACT

In this paper, an array of square monopole antenna using a Frequency Selective Surface layer having a high gain is proposed. The FSS layer reflector is placed below the microstrip line fed monopole antenna. The monopole and FSS layer are designed on duroid and FR4 substrate respectively. The antenna is operated on WiMax bands. The antenna structure dimensions are 213 mm × 213 mm.

Keywords—*Square Monopole Antenna; FSS layer; high gain antenna; WiMax*

I INTRODUCTION

Ultra– Wideband (UWB) technology supports numerous applications in electronics product, impulse radio, communication system and radar. The wideband antennas in can support several different service bands in the ultra-wideband (UWB) service band, such as WLAN, Worldwide Interoperability for Microwave Access (WiMAX:2.30–2.39,2.50–2.69,3.4–3.8,and5.72–5.85GHz), and Satellite Digital Multimedia Broadcasting (S-DMB: 2.605–2.655 GHz)[2-3].

Frequency-Selective Surface (FSS) is a repetitive surface designed to reflect, transmit or absorb electromagnetic fields.Planar and Frequency Selective Surface (FSS) are used to increase the gain of UWB antenna. FSS reflectors are also used to improve the gain of UWB antennas. FSSs comprise of an array of similar type of elements or cells repeated in the two dimensional geometry with known periodicity. These elements may be patches or slots.Their properties can be engineered to exhibit band-pass, band-stop, low-pass, or high-pass characteristics depending on design[4-6].

FSSs can be energized by incident waves or by individual source for each element of FSS. The array excited by earlier method is called passive array or FSS while the array excited by second method is termed as active array or FSS. FSS exhibits the properties of a band stop filter where the electromagnetic waves incident on it are reflected[6].

The monopole antennas gives high impedance bandwidth with good radiation pattern in azimuthal plane. The printed monopole antenna can be seen as a specialcaseofmicrostripantenna configuration whereinthe backing ground plane is located at infinity. A patch is fabricated on dielectric substrate. Beyond the substrate it can be

assumed that a very thick air dielectric substrate (εr =1) exists. It makes a microstrip antenna configuration on a thick substratethatgives high bandwidth[4-6].

In this paper a 1x2 array of square monopole antenna using FSS as a reflector is proposed. Maximum gain of 8.59 dBi is obtained over 3.3 GHz. The following sections present the antenna geometry, design theory, simulation results.

II ANTENNA DESIGN & THEORY

The geometry of antenna is shown. Fig. 1(b) shows the 1x2 array of antenna structure. The antenna is a 1x2 array of Square Monopole Antenna designed on duroid substrate having thickness of 0.787mm and dielectric constant εr=2.2 and tanδ=0.0009.

Fig. 1(c) shows the geometry of the FSS layer antenna. The Frequency Selective Surface layer is designed on a FR4 substrate having thickness of 1.6 mm and dielectric constant εr=4.4 and loss tangent tanδ=0.02.

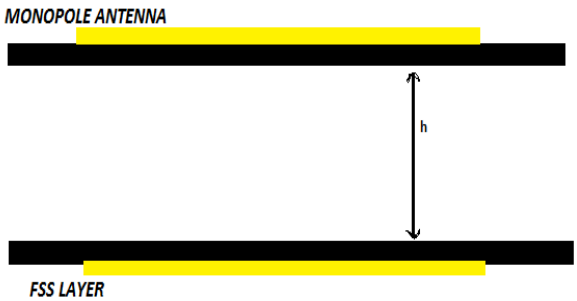
For a square monopole antenna, the lower frequency fL corresponding to VSWR = 2 is calculated by

$$f_L = \frac{c}{\lambda} \quad (1)$$

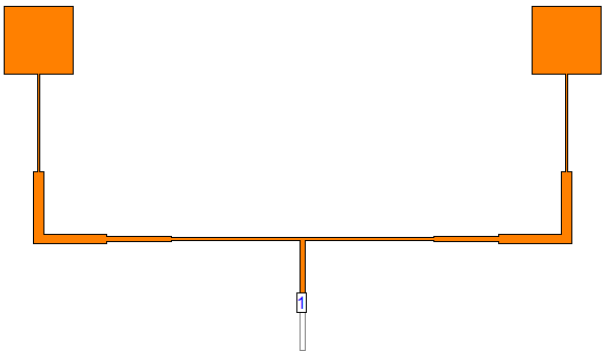
where L is the height of the monopole antenna in cm, r is the effective radius of the equivalent cylindrical monopole antenna in cm and g is the gap between ground plane and monopole structure[4].
For a square monopole antenna, the equivalent values of L and r are: L = S and r = S/2π. Then,

$$f_L = \frac{c}{\lambda} = \quad (2)$$

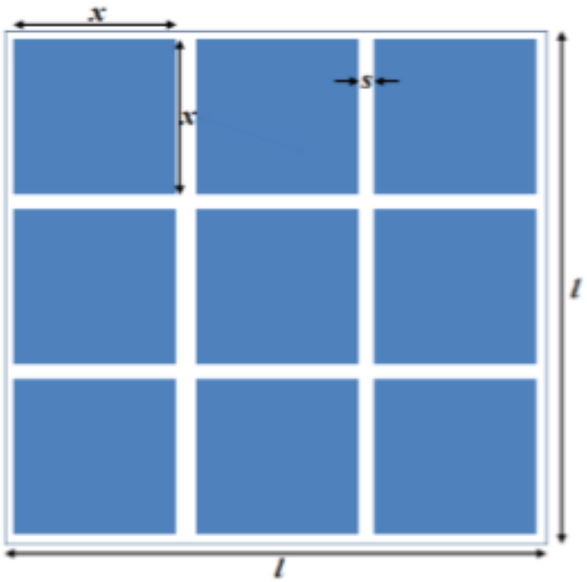
The 1x2-array square monopole antenna is fed through a 50 Ω microstrip line. The Frequency Selective Surface (FSS) layer is placed below the antenna. The distance of FSS layer from the antenna is important for the waves reflected from FSS to be in constructive phase with the waves radiated from the monopole antenna. The Frequency Selective Surface(FSS) layer consists of an array of square patches fabricated on FR4 substrate of 1.6 mm thickness having dielectric constant = 4.4 and loss tangent = 0.02. The gap between the patches acts as a capacitor and the patches act as inductors. Thus, FSS acts as a band pass filter and affects the amplitude and the phase of the fields reflected from this FSS layer.The FSS layer consists of 3×3 square patch array of length ‘x’ each with uniform spacing ‘s’. FSS layer has dimensions of 213 mm × 213 mm. The structures are optimized using Zealand IE3D software. The optimum dimensions of antenna are tabulated in Table I.



(a)



(b)



(c)

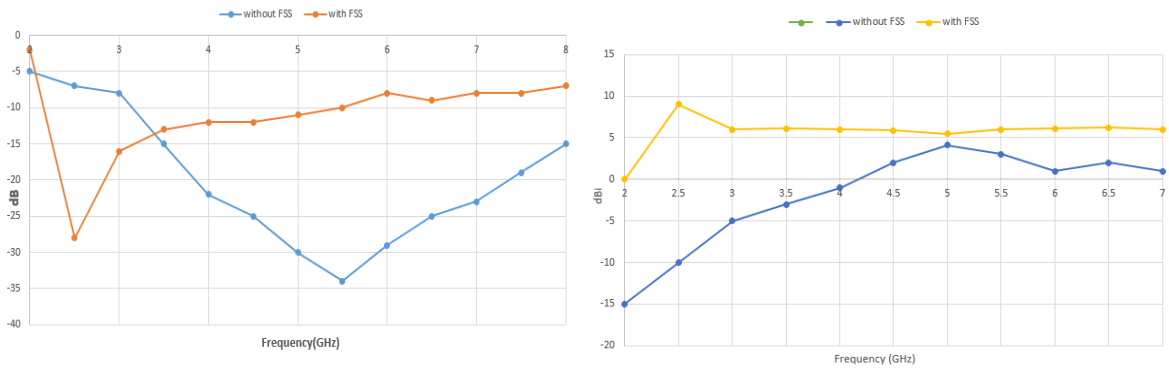
Fig. 1: (a) Antenna with FSS reflector (b)1x2 array Square monopole antenna (c)Frequency Selective Surface layer.

TABLE I. Optimum Dimensions (in mm) of Proposed Antenna Structure

f_L(GHz)	x	g	h	s
3.3	70	0	16	1

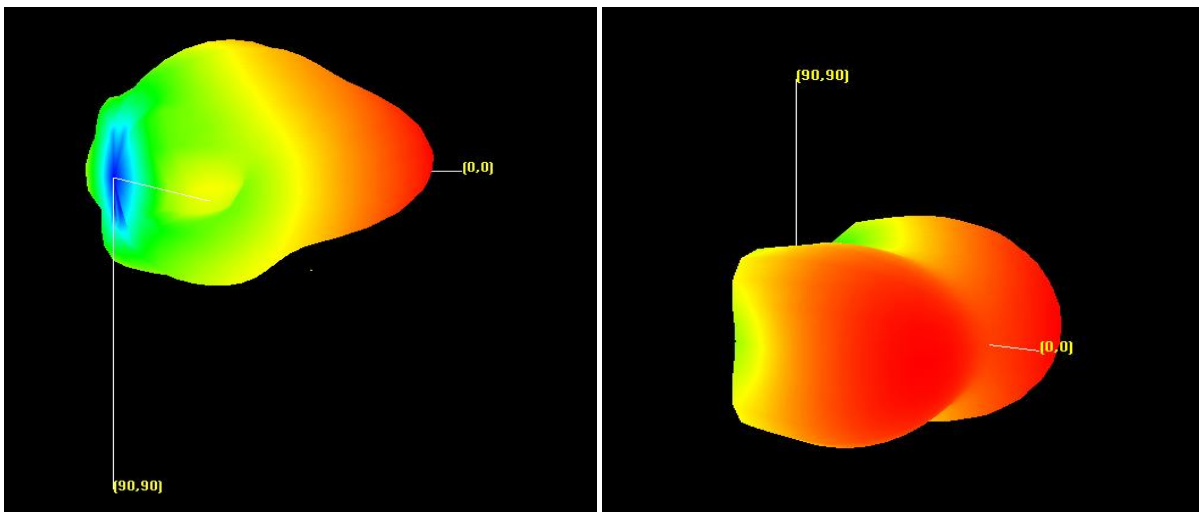
III. SIMULATION RESULTS & ANALYSIS

The Frequency Selective Surface (FSS) layer is placed below the 1x2 array of square monopole antenna. The S_{11} & the gain variation between the 1x2 array of square monopole antennaand FSS reflector is shown in Fig. 2(a) & 2(b).As can be seen that the Gain of the 1x2-array square monopole antenna with Frequency Selective Surface reflector is considerably increased then the antenna without Frequency Selective Surface layer. The gain with FSS reflector is 8.7 dBi that is a considerable increase from the results of antenna without FSS reflector. Similarly, the S_{11} graph is also shown.



(a) (b)

Fig. 2: (a) S_{11} and (b) Gain variation of 1x2 array square monopole antenna with and without FSS at f_L=3.3GHz.



(a) (b)

Fig. 3: 3D radiation patterns (a) with FSS (b) without FSS

IV. CONCLUSION

A 1x2 array of square monopole antenna with a Frequency Selective Surface reflector is proposed. Maximum gain of 8.7 dBi is obtained when operated at 3.3 GHz, which is the WiMAX operating frequency. This proposed antenna can be used for WiMAX applications as well as various UWB applications.

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