Enhanced Gain Square Monopole Antenna using FSS Layer

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ABSTRACT
In this paper, a 1x2 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 2.3 GHz WiMAX band frequency. The antenna structure dimensions are 213 mm × 213 mm.

Keywords
Square Monopole Antenna; FSS layer; high gain antenna; WiMax bands

1. 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,and 5.72–5.85GHz), and Satellite Digital Multimedia Broadcasting (S-DMB: 2.605–2.655 GHz)[2-3].

Frequency Selective Surfaces (FSS) 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. Planar and Frequency Selective Surface (FSS) are used to increase the gain of UWB antenna. 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. Monopole antennas are a special case of microstrip antenna configuration wherein the 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 ($\varepsilon r = 1$) exists. It makes a microstrip antenna configuration on a thick substrate that gives high bandwidth [4-6].

In this paper a 1x2 array of square monopole antenna using FSS as a reflector is proposed. The antenna is simulated at 2.3 GHz. The following sections present the antenna geometry, design theory, simulation results and analysis.

2. 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 $\tan\delta$=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 $\tan\delta$=0.02.

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

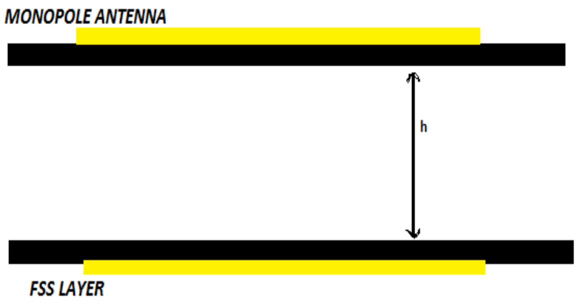
$$f_L = \frac{c}{\lambda} = \frac{7.2}{(L+r+g)} \qquad (1)$$

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].

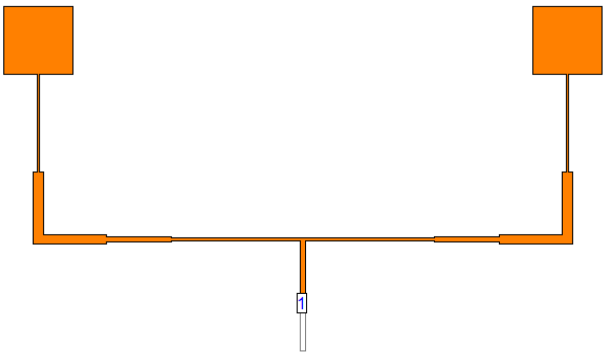
For a square monopole antenna, the equivalent values of L and r are: L = S and r = S/2π. Then,

$$f_L = \frac{c}{\lambda} = \frac{7.2}{(1.16S+g)} \qquad (2)$$

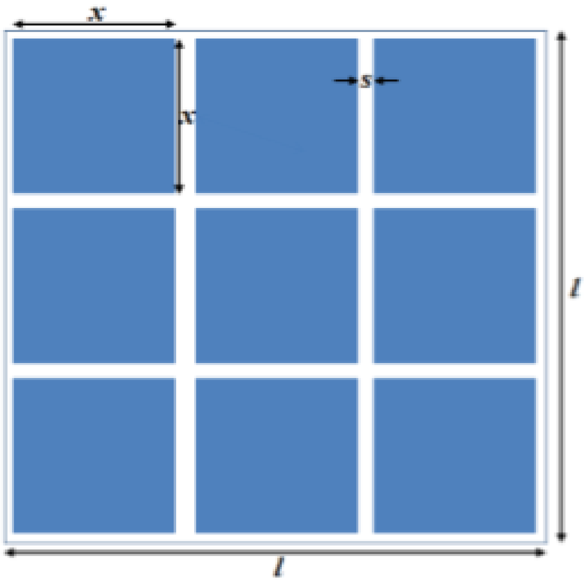
The 1x2-array square monopole antenna is fed through a 50 Ω microstrip line. The Frequency Selective Surface (FSS) layer is placed below the antenna. The distance of FSS layer from the antenna is important for the waves reflected from FSS to be in constructive phase with the waves radiated from the monopole 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
2.3	70	0	16	1

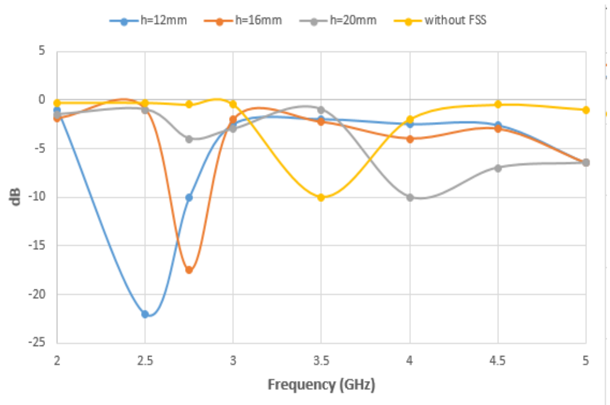
3. SIMULATION RESULTS & ANALYSIS

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 antenna and FSS reflector for various cases is shown below.

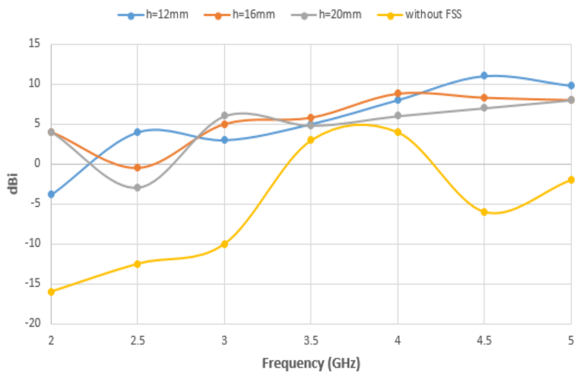
A. Effect of FSS reflector height 'h'

The S_{11} and gain variation for different reflector height 'h' of Frequency Selective Surface layer are shown below in Fig. 2(a) and (b) respectively.

S_{11} degrades with decrease in reflector height due to mismatch caused by reflections. However, the antenna gain increases with decrease in reflector height. This is due to the increase in effective electrical size of the reflector with decrease in reflector height.



(a)



(b)

Fig. 2: (a) S_{11} and (b) Gain vs Frequency variation for different heights 'h' at 2.3GHz.

B. Effect of patch size 'x'

The S_{11} and gain variation for different patch size 'x' of Frequency Selective Surface layer are shown below in Fig. 3(a) and (b) respectively. The resonating frequency of the antenna depends on FSS patch size. As the patch size increases the inductance of patch increases, therefore the resonant frequency decreases. FSS patch size also affects the impedance matching and gain of the antenna. At higher frequency as the patch size decreases, S11 improves and therefore, maximum gain is obtained.

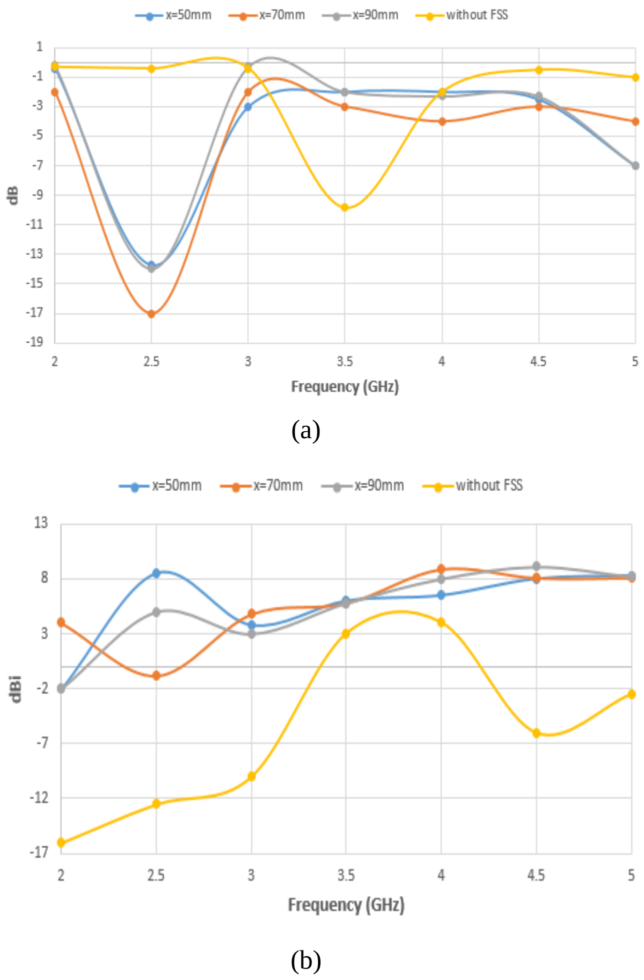


Fig. 3: (a) S_{11} and (b) Gain vs Frequency variation for different patch size 'x' at 2.3GHz.

4. CONCLUSION

A 1x2 array of square monopole antenna with a Frequency Selective Surface reflector is proposed. The analysis with respect to FSS reflector height and patch size is done. Maximum gain of 10.2 dBi is obtained when operated at 2.3 GHz, which is the WiMAX frequency. This proposed antenna can be used for WiMAX applications as well as various UWB applications.

5. REFERENCES

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