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CIRCULAR MONOPOLE SLOTTED ANTENNA WITH FSS FOR HIGH GAIN APPLICATIONS

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ABSTRACT

A coplanar waveguide feel wideband antennas are designed with slots on the radiating element and stubs on ground plane. Proposed model 1 exhibiting notch band characteristics at desired frequencies (3.5-4.5 GHz, 7.5-8 GHz) and model 2 is designed to operate in the ultra-wide band region. To enhance the gain characteristics of the proposed models incorporated a mushroom structured like frequency selective surface as reflecting device beneath the antenna structure. By placing FSS structure a stable gain of 7dB is attained from model 1 and 5dB in model 2. The experimental results of the proposed wide band antenna of model 1 are in good correlation with the simulated results from HFSS.

Keywords: circular monopole, slotted antenna, frequency selective surface (FSS), gain, wideband.

1. INTRODUCTION

There is always demand for the high gain antennas with desired bandwidth for ultra wide band communication. The federal communication commission (FCC) proposed 3.1-10.6 GHz as ultra wide band range for communication operations [1-2]. So, number of researchers proposed different novel designs of micro strip antennas which can work in the desired band of operation. The main drawback in the design of wide band antennas for UWB communication applications lies in the gain characteristics of the antenna [3-5]. Generally for any antenna, if bandwidth is more, then obviously gain will be decreased. By keeping this point in the designer mind we proposed two novel structures of micro strip antenna designs which can work in the wide band region with considerable gain [6-10].

Initially in designed models 1 is exhibiting dual band characteristics with notching at selected bands. Model 2 exhibits wide band characteristics between 3.2 - 14 GHz with bandwidth of 10.8 GHz. High bandwidth is attained for these models but gain is very low. To enhance the gain characteristics a frequency selective surface structure is incorporated in the design. The FSS is also called high impedance surface and when we use this properly at a particular place we can offer in phase reflection over a wideband and improvement in the impedance matching also occurs.

In this paper a compact circular monopole antenna models are designed at dedicated frequencies and wideband frequency for UWB applications. To improve the gain of the antenna a frequency selective surface is designed and implemented [11-16]. The frequency selective surface is a square loop printed on both sides of substrate and placed beneath the antenna to act as reflector. Finite element method based electromagnetic tool HFSS is used in the design of proposed models and antenna is prototyped on FR4 substrate with dielectric constant 4.4 and height 1.6mm.The measured results from the prototyped antenna are collected from ZNB 20 vector network analyzer which is available at R&D center of K L University.

2. ANTENNA GEOMETRY

Figure-1 shows the circular monopole notch band antenna with radiating stubs on two sides of ground plane. The antenna is occupying the overall dimensions 64 x 56 x 1.6 mm. The circular patch consisting of a semi-circular slot of radius 5mm to notch a particular band, An U shaped slot is created on the field line. To notch another band two slots are taken on the ground plane are shown in Figure-1. The stubs which are added on the ground plane are responsible for the notch band characteristics. Figure-2 shows the modified structure of the antenna Model1 without stubs and slots on the feed line. On the circular patch semicircular slot is created nearer to the feed line as shown in Figure-2. By removing notch band related slot on the feed line and by adjusting the slot on the radiating element, we attained wide band characteristics from Model 2. The overall dimensions of both the models are presented in Table-1.

Model 1

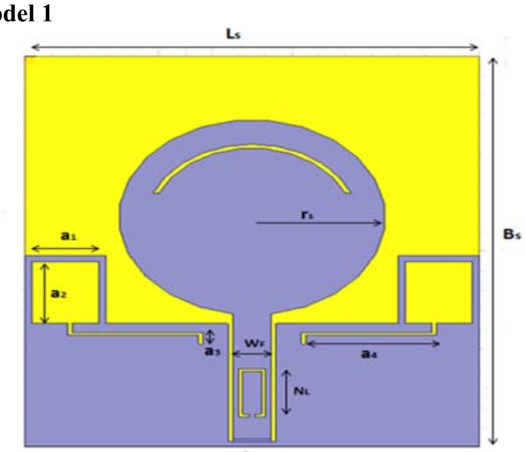

Figure-1. Circular monopole antenna Model 1.

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Model 2

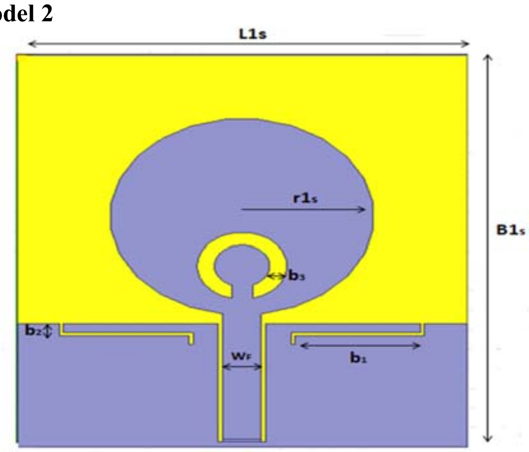

Figure-2. Circular monopole antenna model 2.

3. RESULTS AND DISCUSSIONS

The designed models are initially simulated on HFSS tool and resultant antenna parameters are presented in this section, Figure-3 shows the reflection coefficient curve for the antenna Model 1 and Model 2. From this figure we observed that the antenna Model 1 is notching dual band and antenna Model 2 is resonating in wide band. The antenna 1is showing an impedance bandwidth of 50% at first resonant frequency and impedance bandwidth of 54%. Antenna Model 2 is working between 3.4 GHz to 14 GHz with bandwidth of 10.6 GHz. The antenna Model 2 is providing an impedance bandwidth of 124% at the operating center frequency.

Figure-4 shows that impedance characteristics of the designed antenna models over the operating frequency band. Antenna 1 is showing better impedance characteristics compared to antenna Model 2. Figure-5 shows the radiation characteristics of Model 1 at 6 GHz. It is been observed that antenna is showing a monopole like radiation in the E-field and oval like radiation in the H-Plane. At 9 GHz antenna is showing quasi -Omni directional radiation pattern in the quasi H-plane and dipole like radiation in the E-plane.

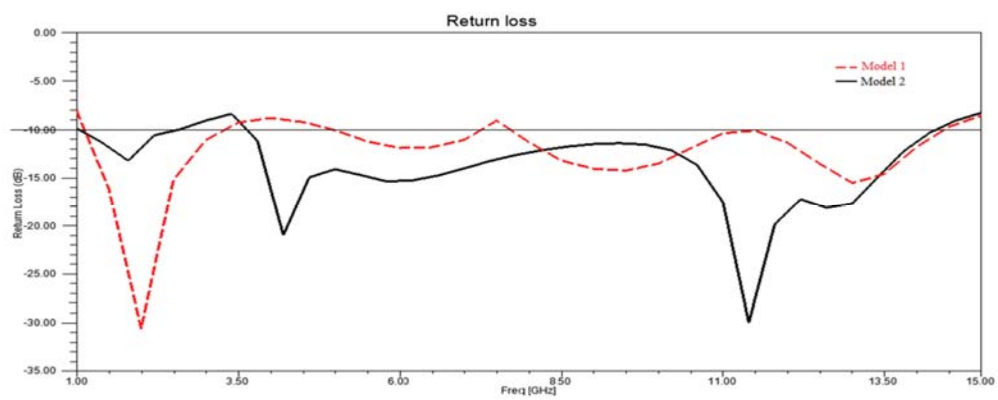

Figure-3. Reflection coefficient of antenna models.

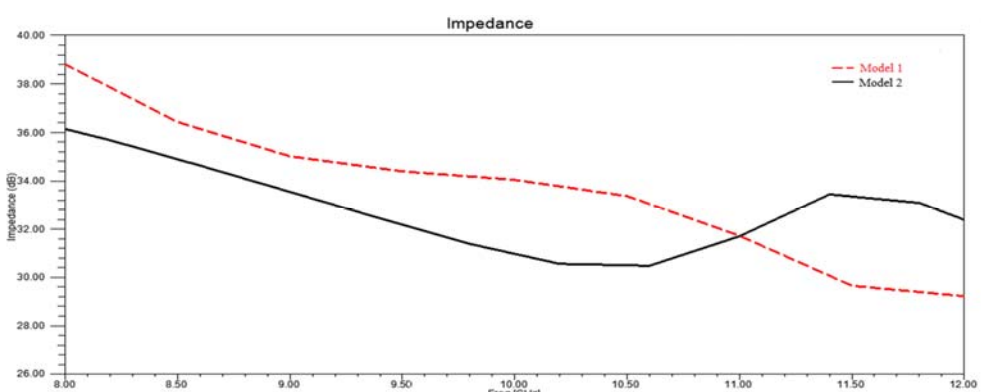

Figure-4. Impedance vs frequency.

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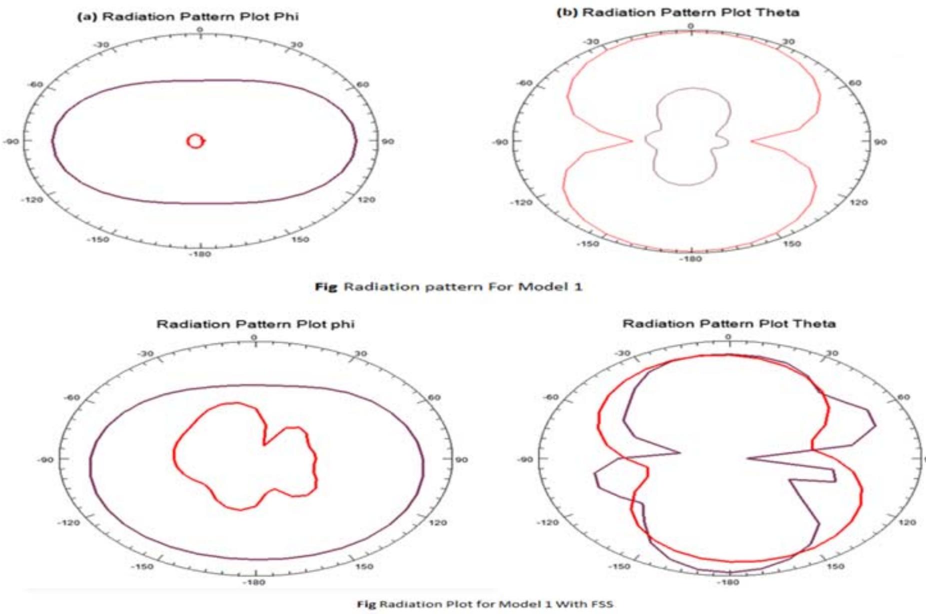

Figure-5. Radiation pattern of model 1 at 6 GHz and 9 GHz in E and H-Plane.

A 5 X 5 square loop FSS is designed to improve the gain of the antenna models. The FSS is formed by printing metallic loops on both sides of FR4 substrate of relative permittivity of 4.4 and thickness 1.6 mm. Figure-6 shows the current distribution of antenna Model 2 with and without FSS. In this case most of the current density is focused on the top side of the ground plane and on the nearer edges of the feed line to ground plane. The radiation coming out of Model 2 is mostly because of the edges of feed line and ground plane.

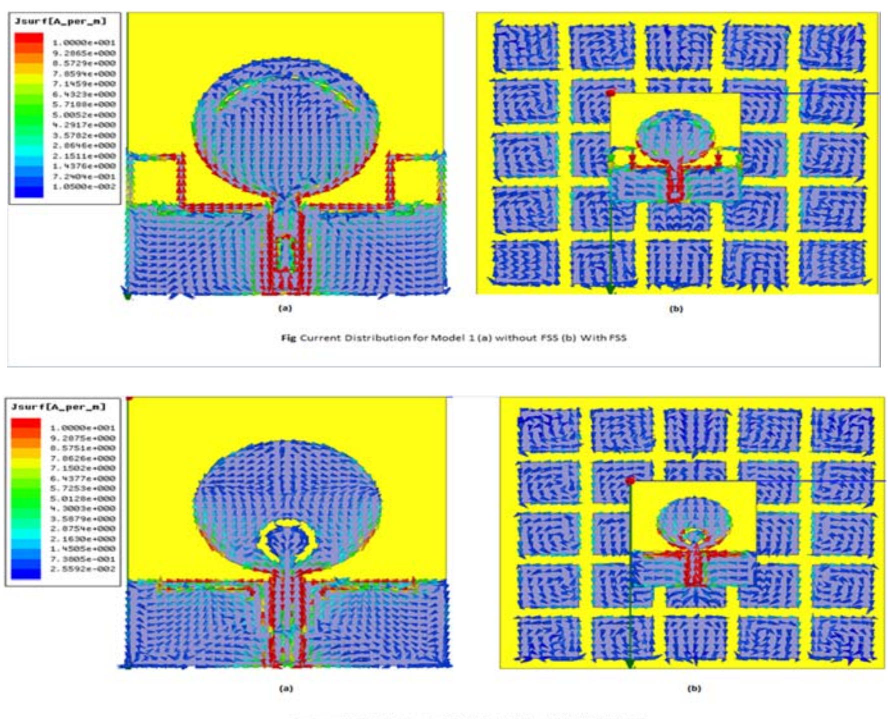

Figure-6. Current distribution of the antenna models 1 and 2.

VOL. 11, NO. 15, AUGUST 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

Figure-7 shows the gain plot of antenna Model 1 with and without FSS. Without FSS antenna is showing very low gain at resonating frequencies but with FSS a peak realized gain of almost 8dB is attained.

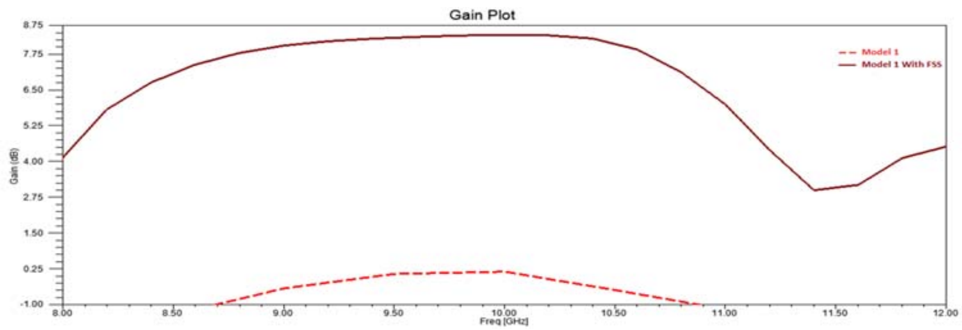

Figure-7. Gain Vs frequency of model 1.

Figure-8 shows the directivity of antenna with and without FSS.A peak directivity of 2.4 dB is attained for the case of with FSS antenna Model 1.

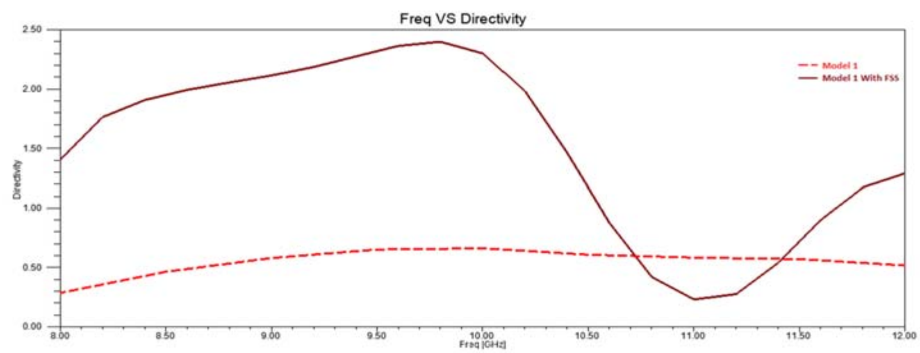

Figure-8. Directivity vs frequency of model 1.

Figure-9 shows the gain plot of antenna model 2. With FSS gain is increased tremendously in the operating band with average value of 5dB.The antenna Model 2 is giving large bandwidth and stable gain of 5dB.

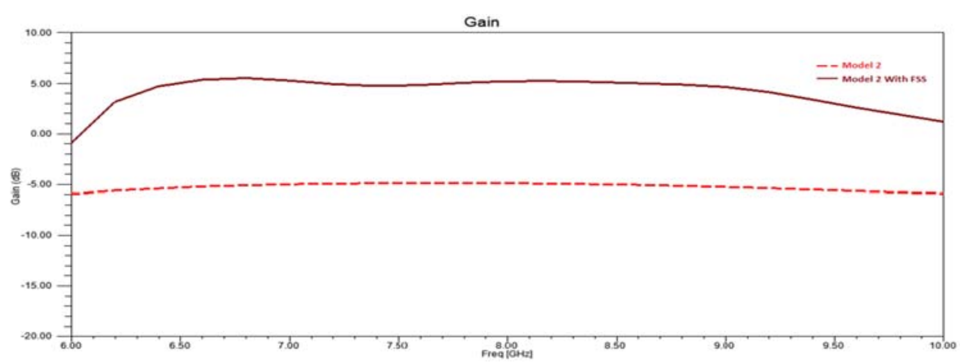

Figure-9. Gain vs frequency of model 2.

Figure-10 shows the frequency Vs directivity of antenna Model 2. A peak diversity value of 3.4 dB and an average directivity value of 2.5dB are attained for the antenna Model 2 with FSS.

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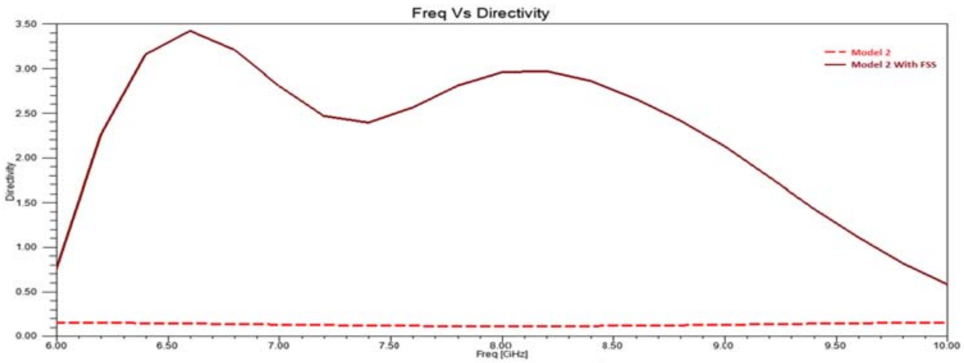

Figure-10. Directivity vs frequency of model 2.

The radiation pattern of deigned Models with FSS is shown in Figure-11 and Figure-12. Antenna Model 1 with FSS is showing Omni-directional radiation pattern in the H-plane and directive radiation pattern in E-plane. Antenna Model 2 with FSS is also providing similar kind of results in H-plane but E-plane radiation pattern is distributed.

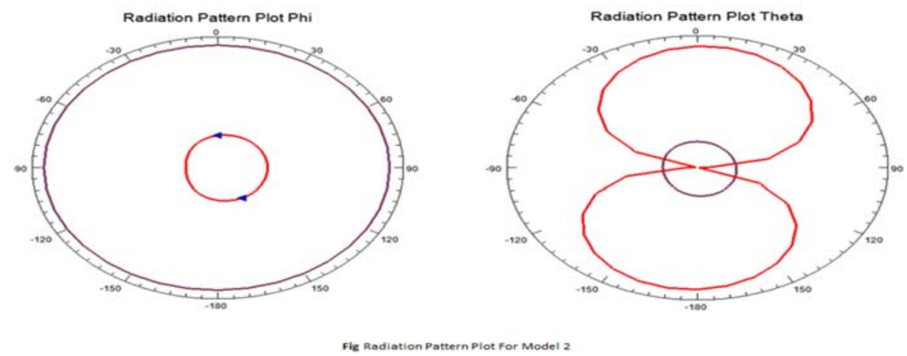

Figure-11. Radiation pattern of Model 1 with FSS in E and H-Plane.

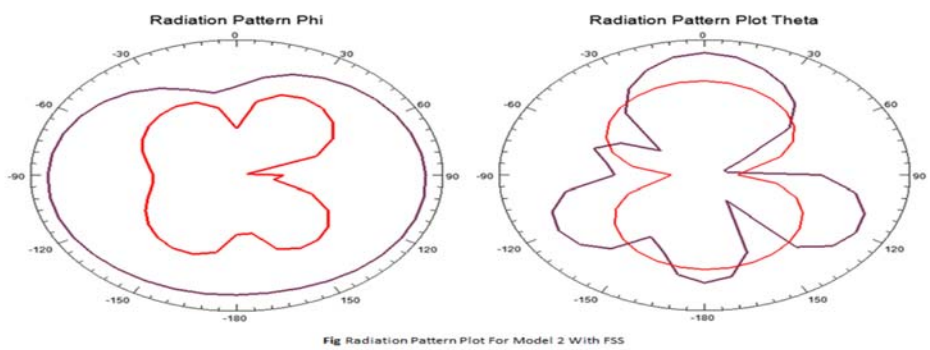

Figure-12. Radiation pattern of model 2 with FSS in E and H-Plane.

Figure-13 shows 3-D radiation pattern of antenna models with and without FSS. Figure-14 shows current distribution on Antenna Model 1 at fundamental resonant frequency.

VOL. 11, NO. 15, AUGUST 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

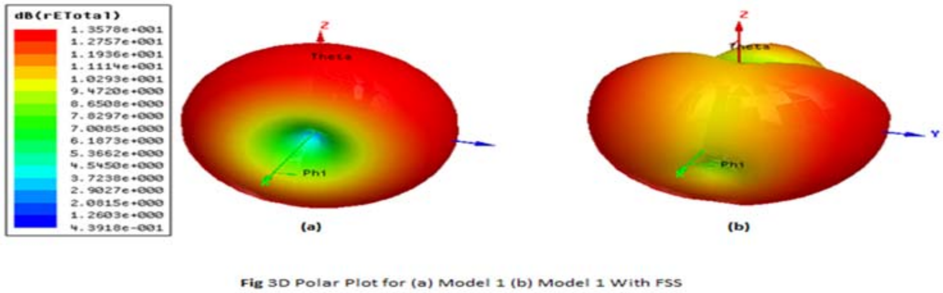

Figure-13. Three dimensional view of radiation pattern for two models with FSS.

The FSS is acting as a reflector and most of the current is focused at feed line and on the additional stubs nearer to ground plane.

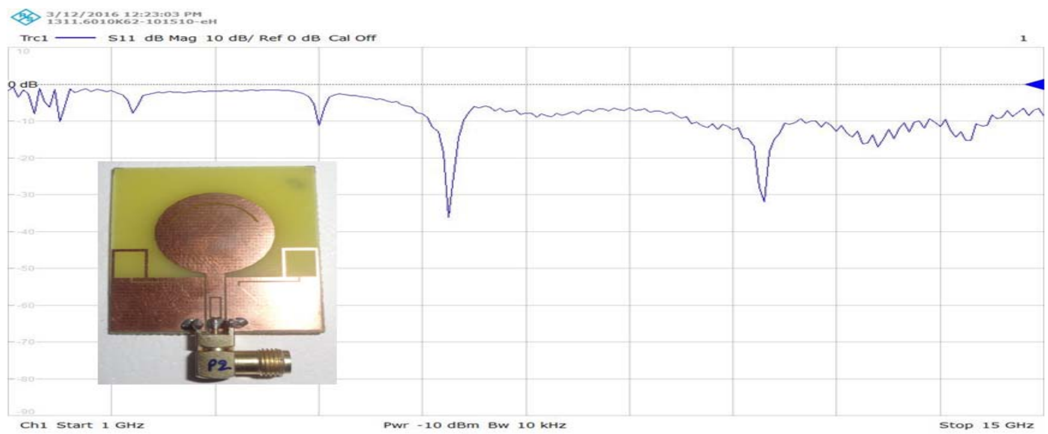

Figure-14. Prototyped antenna measurement results on ZNB 20 VNA.

Antenna model 1 is prototyped on FR4 substrate and tested on ZNB 20 vector network analyzer. The measured results are also showing similar kind of characteristics when compared with simulation results on HFSS tool. Figure-14 furnished that measured results from vector network analyzer, which is available in the RHS and LC R and D of K L University.

4. CONCLUSIONS

Circular monopole antenna models are designed to operate in the wideband. The gain of the proposed antenna models are improved by placing frequency selective surface beneath the antenna ground terminal with some distance. By placing FSS structure a stable gain of 7dB is attained from model 1 and 5dB from model 2. A peak directivity of 2.4 dB is attained from model 1 and 3.4 dB is attained from model 2. The prototyped antenna model 1 is tested on ZNB 20 vector network analyzer. The experimental results of the proposed wide band antenna of model 1 are in good correlation with the simulated results from HFSS.

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