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BANDWIDTH ENHANCEMENT USING PARASITIC PATCH FOR KU BAND

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Abstract:- A design of microstrip patch antenna with prime focused of increasing bandwidth using various techniques of probe feed, parasitic patch around the main patch and two layer of substrate. The simulation process has been done using HFSS (High frequency Structural Simulator). In this paper, authors cover six aspect of microstrip antenna designs. The first is analysis of single element narrowband rectangular microstrip antenna which operates at central frequency of 14.3 GHz. The second/third aspect is design of two gap/direct coupled patch along main patch. The fourth/fifth aspect is analysis and design of four gap/direct coupled parasitic patch along main patch and in sixth aspect is analysis and design of two layer of substrate in parasitic patch design. The properties of antenna such as bandwidth, S parameter, VSWR, Gain has been investigated and compared.

Keywords- Bandwidth, HFSS, MSA, Parasitic Patch, Return loss, VSWR

INTRODUCTION

In recent years great interest was focused on microstrip antenna has numerous advantage, it has inherent limitation of narrow impedance bandwidth and low gain, many techniques have been suggested and investigated for MSA. Microstrip antenna has its remarkable advantage over conventional antennas, such as small size, low weight, easy to fabricate, compatibility to planar and non-planar surfaces, ease of being integrated with circuits, mechanically robust, simplicity of creating antenna arrays and suitable for multi-frequency operation. These attractive features made patch antenna more applicable in many communication systems. Their further use in specific system is limited because of their relatively narrow bandwidth. Intensive research has been carried out to develop the bandwidth enhancement techniques by keeping the size of the patch antenna as small as possible. Several bandwidth enhancement techniques like thick substrate, low dielectric constant substrate material, Using Frequency selective surface for superstrate in EBG antenna [2], printed microstrip line feed slot antenna with parasitic patch [3], Circularly polarized slot antenna [4], multilayer structures [5], rectangular antenna with its radiating edges gap coupled to other element[6].

The Ku-Band defined by an IEEE standard for radar engineering with frequencies that ranges from 12.0 to 18.0 GHz respectively .the Ku band is used for high resolution

mapping and satellite altimetry. Especially Ku band is used for tracking the satellite within the ranges roughly from 12.87 GHz to 14.43 GHz[7,8].

MSA WITH SINGLE PATCH

A microstrip patch antenna consist of a radiating patch on one of dielectric substrate which has a ground plane on the other side. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed line are usually photo etched on the dielectric substrate. In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, and elliptical or some other common.

The pertinent design parameters are given together with their relevant equation to allow basic ' hand' calculations before simulation is attempted. By using this flow of design, simple microstrip patch antenna can implemented. A single element of rectangular patch antenna, as shown in figure 1, can be designed for the 14.3 GHz resonant frequency using transmission line model (step 1,2,3).

In the typical design procedure of the microstrip antenna, the desired resonant frequency, thickness and dielectric constant of the substrate are known or selected initially. In this design of rectangular microstrip antenna, Roger RT/duroid 5880(tm) dielectric material is selected as the substrate with 0.32 mm height. Then, a patch antenna that operates at specify resonant frequency (14.3 GHz) can be designed by the using transmission line model equation.

As shown in figure 2, coaxial probe type feeding mechanism used. The rectangular microstrip patch antenna parameters are:

Resonant frequency fr = 14.3 GHz
Patch width = 5.6 mm
Patch length = 8.2 mm
Substrate height = 0.32 mm
Relative permittivity εr = 2.2
Probe position = (-0.5,0,0)

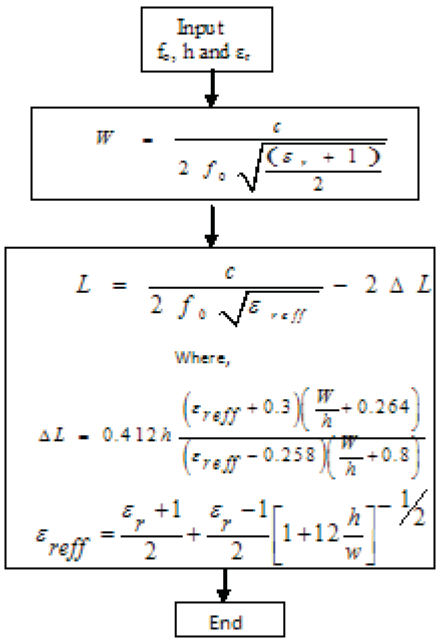

Figure 1. Design flow steps

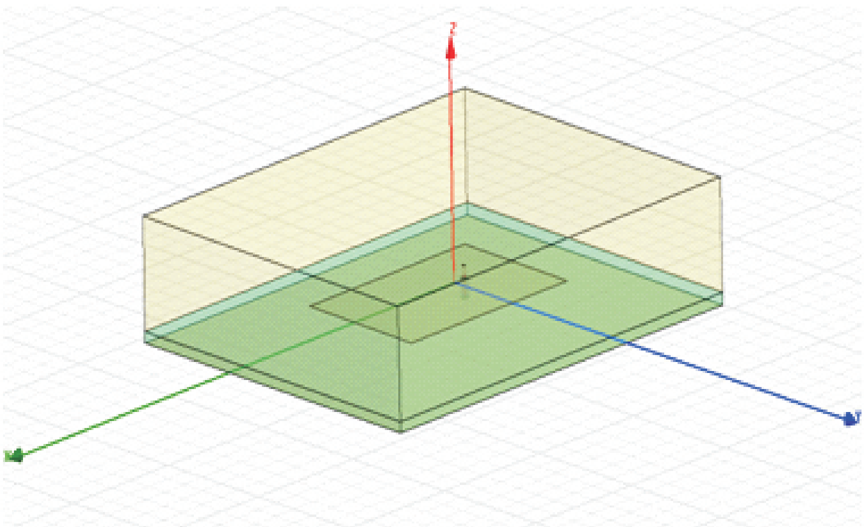

Figure 2. Rectangular MSA with singlr patch

TWO GAP/DIRECT COUPLED PATCH ALONG MAIN PATCH

The main patch consist of two patch along its radiating edge of the patch, supported on a grounded dielectric sheet of thickness h and dielectric constant εr. these two new patches may be electromagnetically or dirct coupled to the main patch. Two patch having the same dimension as main patch. The position of probe fed is best for impedance matching. Two gap/direct coupling patch is shown in figure 3 and 4.

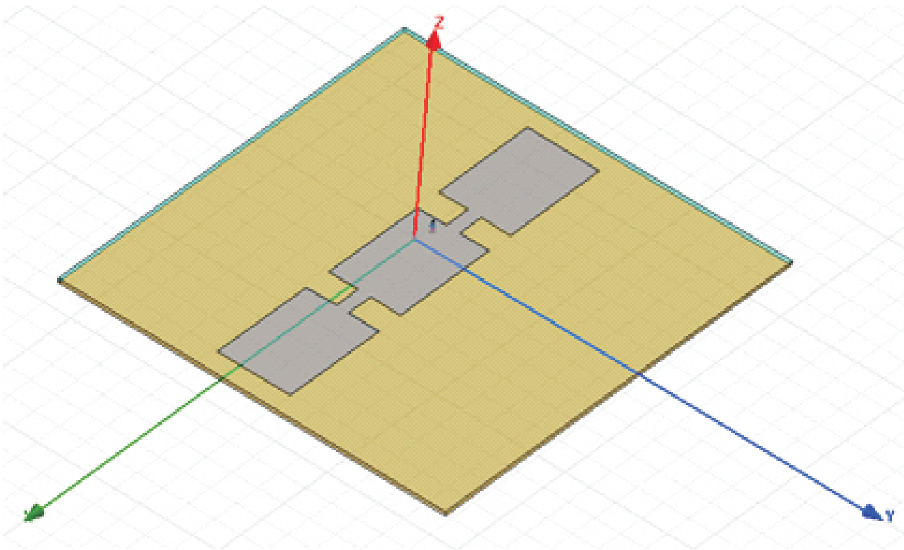

Figure4. Direct coupled two patch along main patch

GAP/DIRECT PARASITIC PATCH ALONG MAIN PATCH

The parasitic patch antenna consist of two parasitic patch along radiating edge and two parasitic patch along non-radiating edge of the main patch; supported on a grounded dielectric sheet of thickness h and dielectric constant εr. These new patches may be coupled to the main patch electro-magnetically or through direct coupling, Each patch has designed a similar manner to the original patch. The position of the probe feed is change in gap coupled and direct coupled antenna because of the impedance matching. Gap/direct coupled parasitic patch antenna is shown in

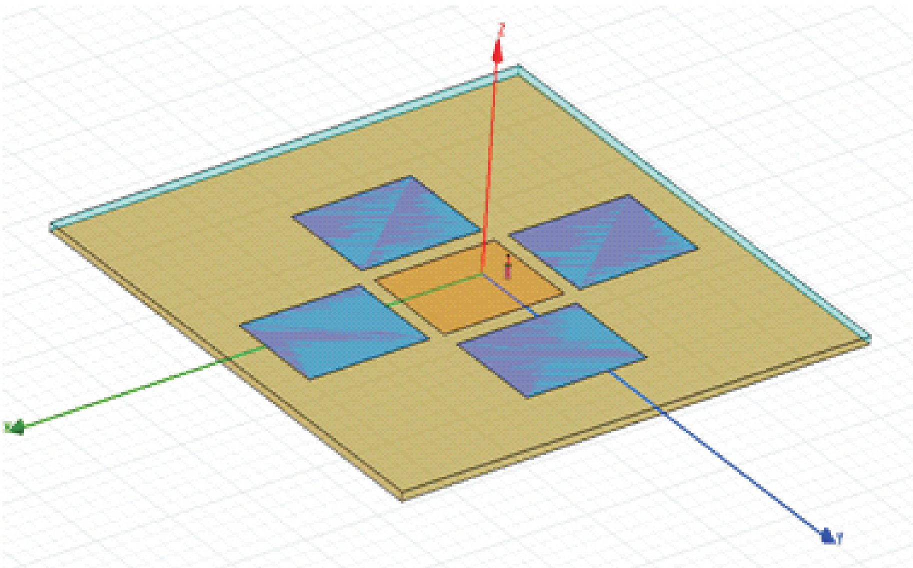

Figure 5. gap coupled parasitic patch antenna

Design parameters of Gap/Direct coupled parasitic patch antenna,

The length L and width W of patches:
Main patch: L = 8.2 mm, W = 5.6 mm
Along radiating edge patch 1: L = 8.2 mm, W =5.6 mm
Along radiating edge patch 2: L = 8.2 mm, W = 5.6 mm
Along non-radiating edge patch 3: L =8.2 mm, W = 5.6 mm
Along non-radiating edge patch 4: L = 8.2 mm,W = 5.6 mm

The chosen substrate is Rogers RT/duroid 5880 (tm) relative permittivity εr =2.2 and height h = 0.32 mm.

Probe position in gap coupled parasitic
patch antenna = (-1.7,0,0).

Probe position in direct coupled parasitic
Patch antenna = (-1.7,0,0).

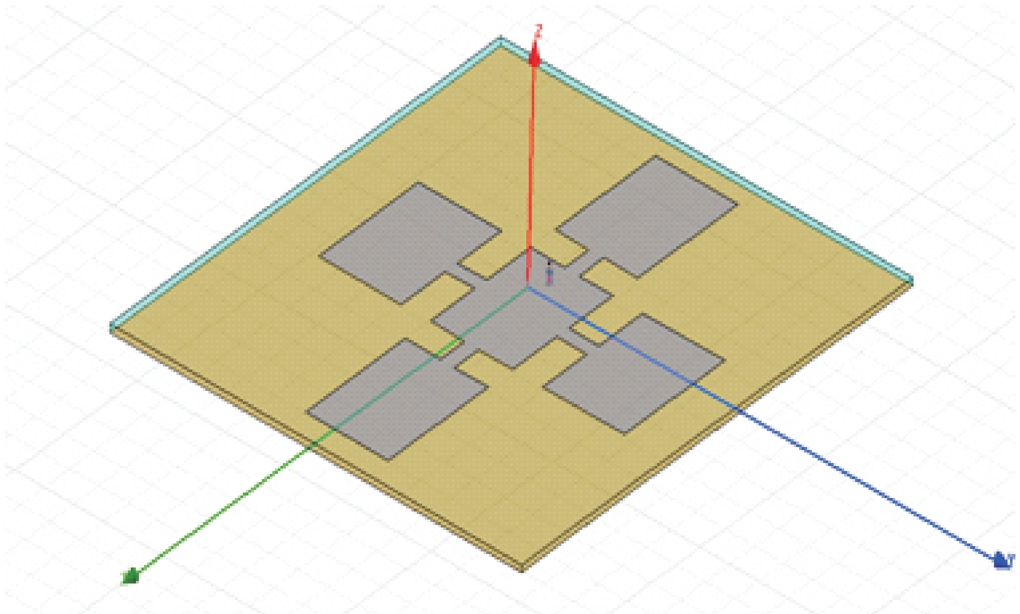

Figure 6. Direct coupled parasitic patch antenna

In both design, bandwidth is enhanced comparatively to single patch antenna design. The dimension and location of the parasitic patch play important role in obtaining the wide bandwidth for the proposed antenna. Actually the separation distance d is very small but variation in it affects the input impedance of an antenna. Here the distance between them is 2 mm.

TWO LAYER OF SUBSTRATE IN PARASITIC PATCH ANTENNA

Using single patch or parasitic patch, bandwidth enhance up to very low percentage. With the two layer of substrate, bandwidth enhance with high result compare to design. Here we used perfect E for patch and ground plane. RT/duroid 5880 (tm) is used for substrate1 and RT/duroid (5870) (tm) is used for substrate2, as shown in figure 7.

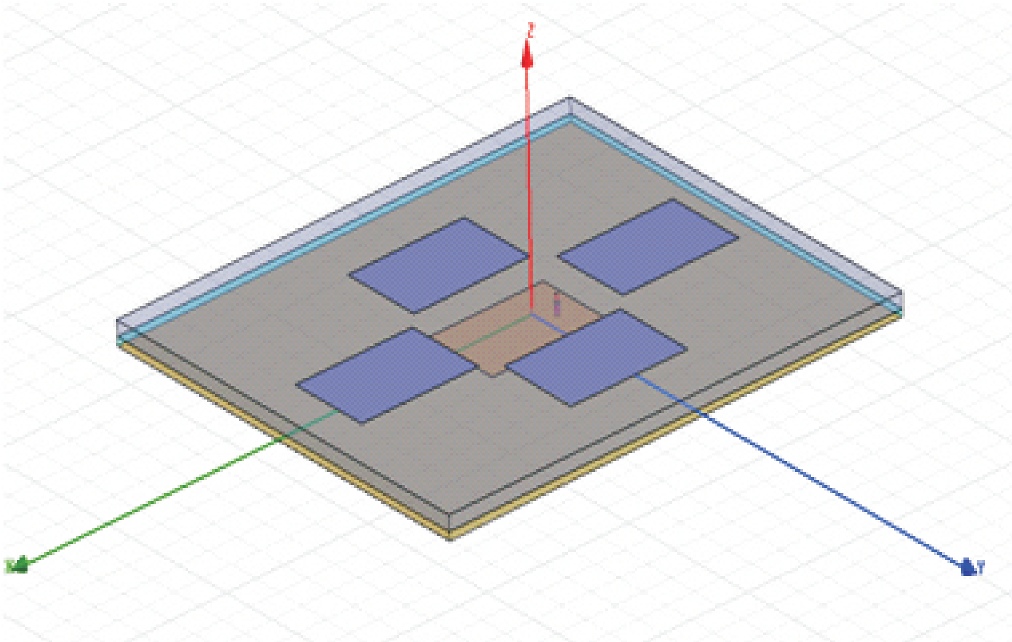

Figure 7. Two layer substrate gap coupled parasitic patch antenna

In this design number of patch, ground and substrate 1 is same. Height of substrate 2 is .64 mm. Here, the position of probe is changed because of impedance matching.

RESULTS

The simulated result of S11 scattering parameter (return loss) of single element rectangular microstrip antenna is presented in figure 8. From the figure, the antenna has almost 16.4322 GHz resonant frequency and it has 400 MHz bandwidth at -10 dB (the difference of 16.2 GHz and 16.6 GHz). In percentage, the bandwidth of the antenna is 2.35 %.

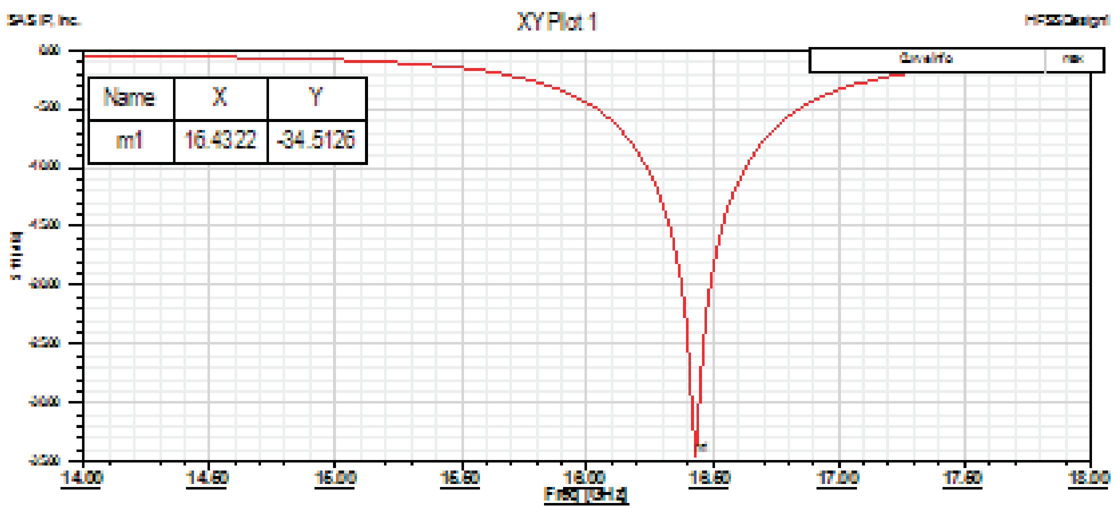

Figure 8. Return loss of MSA with single patch element

The simulated result for radiation pattern is shown in fig 9. The total gain of the antenna is 6.23 dB.The value of VSWR can be seen to be within 1 to 2 in the operating range is best for patch antenna. Here in this design VSWR is 1.08.

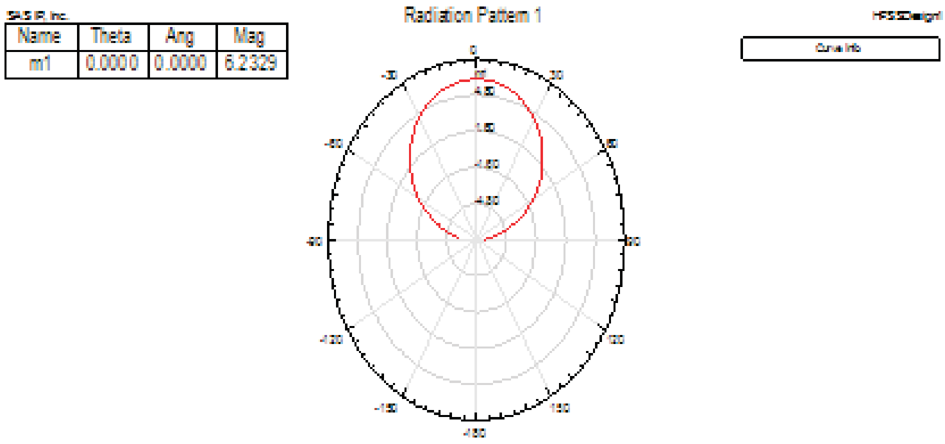

Figure 9.Radiation pattern of MSA with Single patch element

The two patch gap/ direct coupled along main patch, the simulated result of S11 scattering parameter is presented in figure 10. The antenna has almost 16.7538 GHz resonant frequency and it has almost 420 MHz bandwidth at 10 dB (the difference of 16.54 GHz and 16.96 GHz). In percentage, the bandwidth of antenna is 2.50 %.

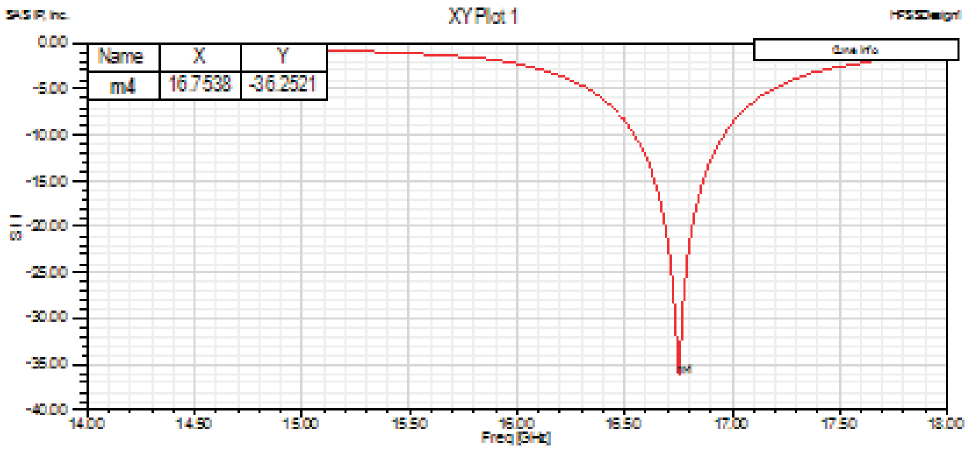

Figure 10. Return loss of two gap coupled patch along main patch

Form figure 11, the antenna has almost 16.7940 MHz bandwidth and it has almost 400 MHz bandwidth at 10 dB (the difference of 16.56 GHz and 16.96 Ghz).

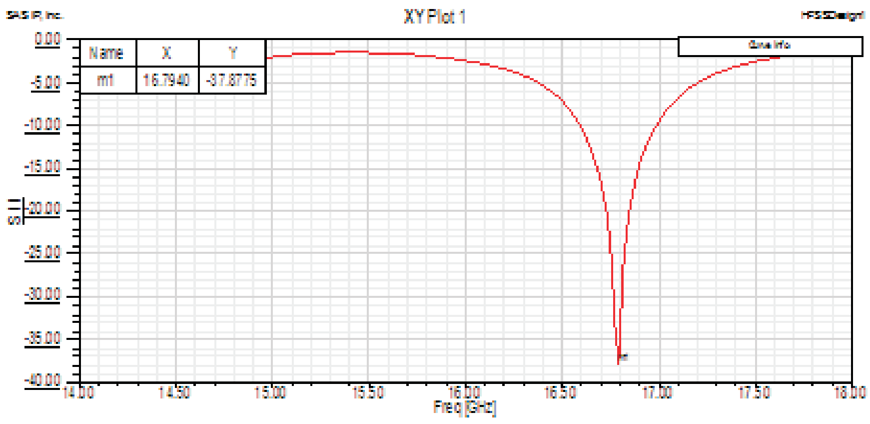

Figure 11. Return loss of two direct coupled patch along main patch

The two patch gap/ direct coupled , the simulated result for radiation pattern is shown in figure 12,13. Total gain of the two gap coupled antenna is found to be 6.40 dB at design frequency of 14.3 GHz. In two patch direct coupled patch antenna total gain is found to be 9.74 dB. The VSWR is found to be 1.03 two gap coupled patch antenna. The VSWR is found to be 1.02 in two direct coupled patch antenna.

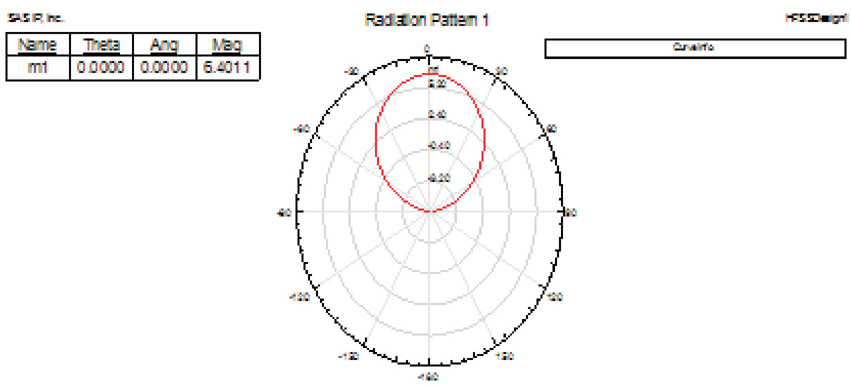

Figure12. Radiation pattern of two gap coupled patch

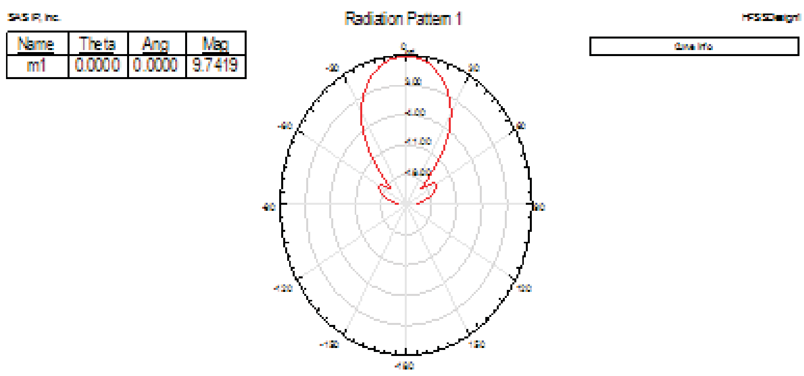

Figure13. Radiation pattern of two patch direct coupled along main patch

In Gap/Direct coupled parasitic patch microstrip antenna, the simulated result of S11 scattering parameter is presented in figure 14, 15. The antenna has almost 16.6432 GHz resonant frequency and it has almost 400 MHz bandwidth at 10 dB (the difference of 16.42 GHz and 16.84 GHz).

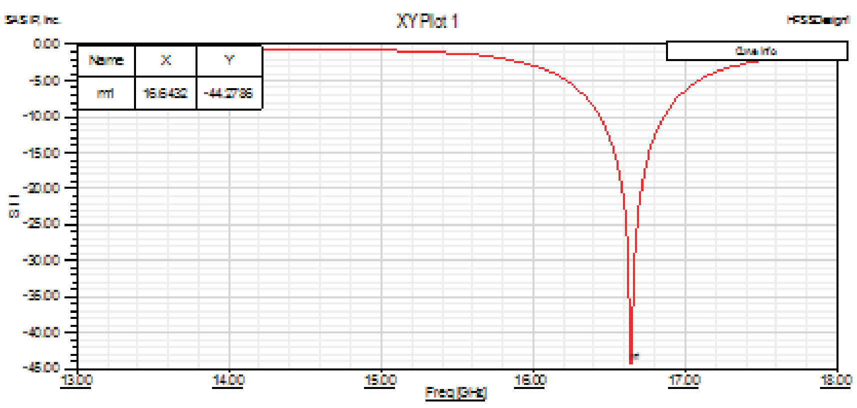

Figure 14. Return loss of Gap coupled patch along main patch

From figure 14, the antenna has almost 18.402 GHz resonant frequency and it has 350 MHz bandwidth at 10 dB (the difference 18.2071 GHz and 18.8557 GHz). In Gap coupled patch along main patch, the VSWR is 1.01 at resonant frequency 16.6432 GHz . In direct coupled patch along main patch , the VSWR is 1.20 at resonant frequency 18.0402 GHz . These values of VSWR is lies between 1 to 2 which is very good for impedance matching purpose.

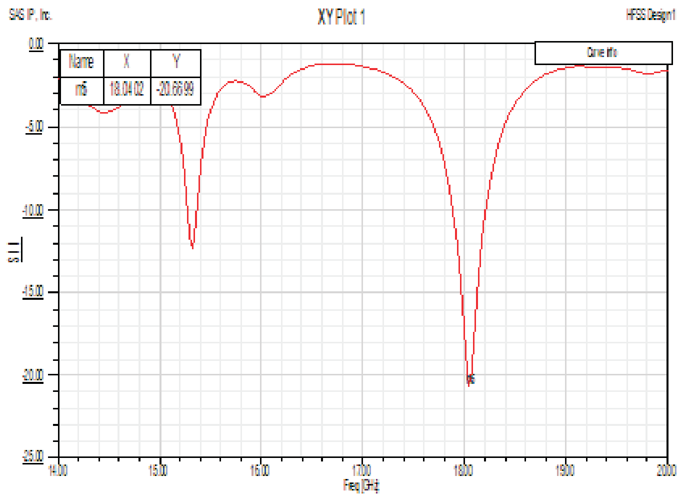

Figure 15, Return loss of Direct coupled patch along main patch

Radiation pattern of gap/ direct coupled patch antenna is shown in fig 16, 17. Total gain in gap coupled patch antenna is found to be 6.01 dB and in direct coupled patch antenna it will be 9.56 dB at deign frequency of 14.3 Ghz.

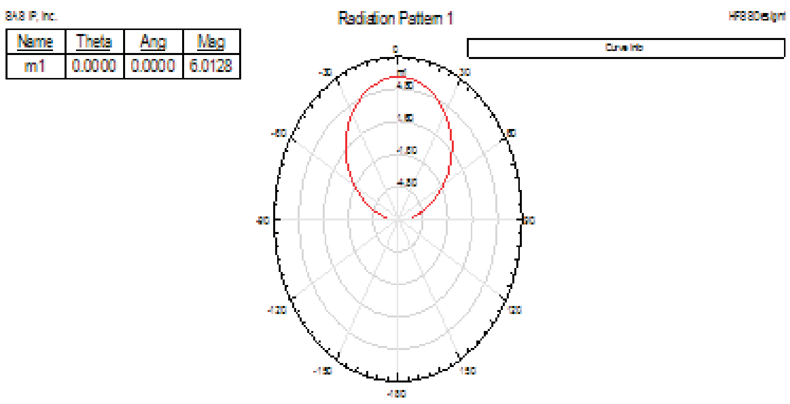

Figure 16. Radiation pattern of Gap coupled patch aling main patch

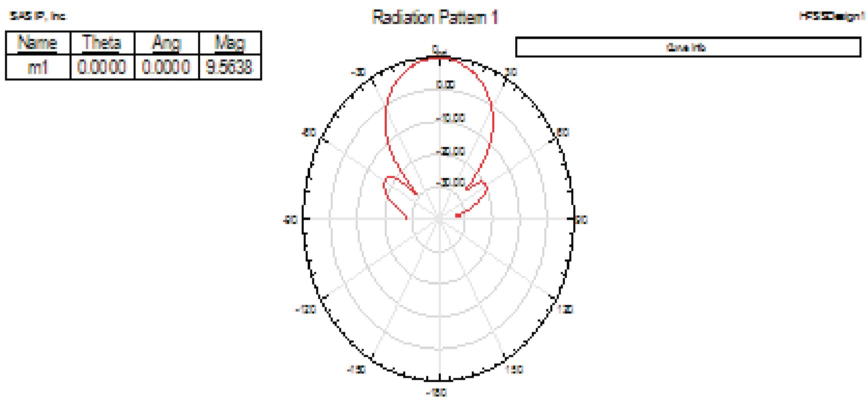

Figure 17. Radiation pattern of Direct coupled patch along main patch

The simulated result of S11 scattering parameter of two layer of substrate in gap coupled parasitic patch microstrip antenna is presented in figure 18. From the figure 18, the antenna has almost 15.9146 GHz resonant frequency and it has 330 MHz bandwidth at 10 dB (the difference of 16.08 GHz and 15.75 Ghz).

In two layer of substrate in gap coupled parasitic patch microstrip antenna the VSWR is 1.01 at resonant frequency 15.9146 GHz.

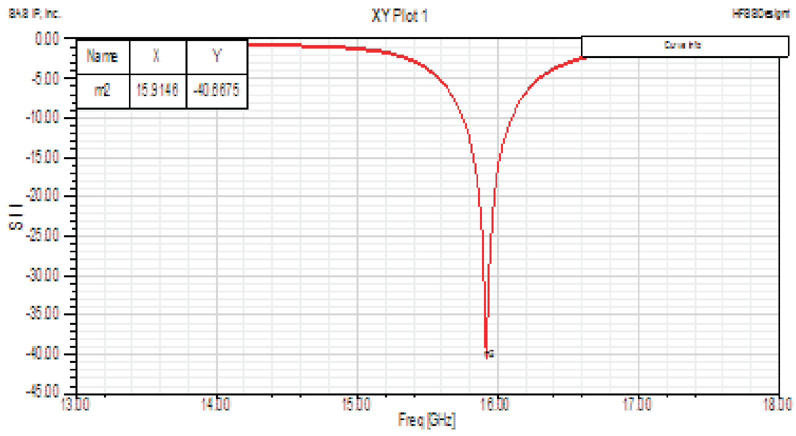

Figure 18. Return loss of two layer of substrate in gap coupled parasitic patch antenna

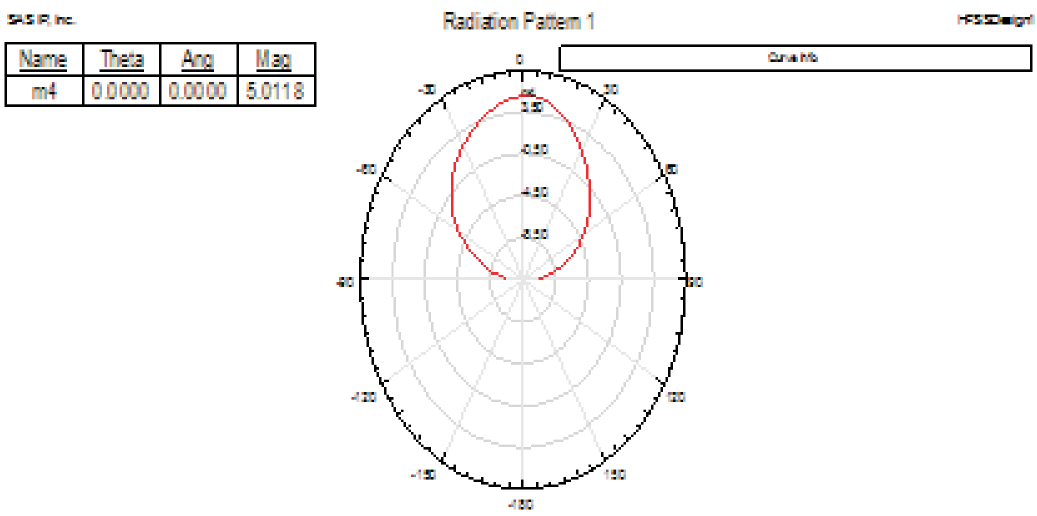

Figure 19. Return loss of two layer of substrate in gap coupled patch antenna

In two layer of substrate gap coupled parasitic patch antenna radiation pattern is shown in figure 19. Form figure total gain of this antenna is found to be 5.01 dB at design frequency 14.3 GHz.

COMPARISON

In this paper, 8.2 x 5.6 mm rectangular microstrip patch antenna fed with contacting method using probe fed contemporary techniques. The rectangular MSA presented with RT/duroid 5880 (tm) substrate and thickness h = 0.32 mm and got a return loss bandwidth 2.35%. Two patch gap/ direct coupled along main patch has a return loss bandwidth 2.50%. With Gap/Direct coupled parasitic patch antenna, we can get bandwidth improvement. By using parasitic patch with two layer of substrate MSA instead of rectangular MSA we can get bandwidth improvement. In table 1 comparison between different parameter like Return loss , VSWR ,gain are described.

TABLE1
COMPARISON BETWEEN RECTANGULAR AND PARASITIC MSA

Design	Return loss (dB)	VSWR	GAIN(dB)
Single patch	-34.51	1.05	6.23
Two patch along main patch gap coupled	-36.25	1.03	6.40
Two patch along main patch direct coupled	-37.87	1.02	9.74
Parasitic Gap coupled	-44.27	1.01	6.01
Parasitic Direct coupled	-20.66	1.20	9.56
Double layer substrate in gap cou[pled	-40.66	1.01	5.01

CONCLUSION

The microstrip patch antenna operating in Ku band is investigated and simulated in this paper. The simulated result for return loss, input impedance and radiation pattern have shown well performance for the operation of this antenna in this antenna. The frequency chosen in this paper is used for satellite tracking as well as Direct broadcast services. From the result we can say that bandwidth improvement up to 3 % in parasitic gap coupled patch antenna. We can also said that in two patch and parasitic patch direct coupling we can have a good gain of 9.74 dB and 9.56 dB.

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