Performance Analysis of High Gain Wide Band Rectangular Patch Antenna using Hybrid Structure

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***Abstract*— A wide band rectangular microstrip patch antenna with high gain characteristics using hybrid structure is proposed in this paper. The antenna is designed at a frequency of 5 GHz and it has wide band characteristics. Here the gain of the antenna is enhanced significantly using hybrid substrates. To provide the hybrid structure an additional rectangular cavity is introduced between the original duroid substrate. The antenna gain is analysed for the four hybrid substrate materials such as benzocyclobuten, Rogers TMM3, Arlon AD250, and Polyquartz. The antenna is energized using the microstrip line feeding method. VSWR of the designed rectangular patch antenna is less than 2. The different characteristics of the antenna such as return loss, gain, directivity, bandwidth, radiated field and VSWR is analysed for different hybrid materials. It is observed that the designed antenna using benzocyclobuten as hybrid material gives the highest gain and bandwidth. The antenna design is simulated by using the software HFSS 13.0.**

***Index Terms*— Microstrip antenna, Resonant Frequency, Microstrip feeding, HFSS, VSWR**

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I. Introduction

Microstrip Patch antennas are simple in design, light weight, low fabrication cost and can be used for various applications such as mobile communication, satellite communication etc. Due to reduction in size of electronic systems, there is also an increasing need of small and low cost antennas [1]. Microstrip Patch antennas are useful antennas for integrated radio frequency front-end systems due to their compatibility with MW integrated circuits. Microwaves are commonly used in various aspects of everyday life. At microwave frequencies the physical size of high gain antenna becomes small enough to make practical the use of suitably shaped reflectors to produce the desired directivity. Bandwidth of the antenna decreased as the dielectric constant of the substrate increases [2].

Electromagnetic waves propagate in all directions when antenna is energized using the appropriate feeding method. Microstrip antenna can be energized by microstrip line, proximity coupling, aperture coupling and coaxial probe method. From these methods of feeding microstrip line feeding method is easy to use and fabricate [3].

II. Antenna Design

The antenna is designed and analysed at a resonant frequency of 5GHz for the different for the different hybrid materials. The substrate used for the designing of the antenna is duroid having dielectric constant of 2.2. Various optimized parameters of antenna are W=26.96 mm, W_1=19.3mm, W_2=3mm, L=28.36mm, L_1=23.72mm, L_2=8.2mm. A rectangular cavity of size 10x10 mm is introduced in the original duroid substrate as shown in Fig.1

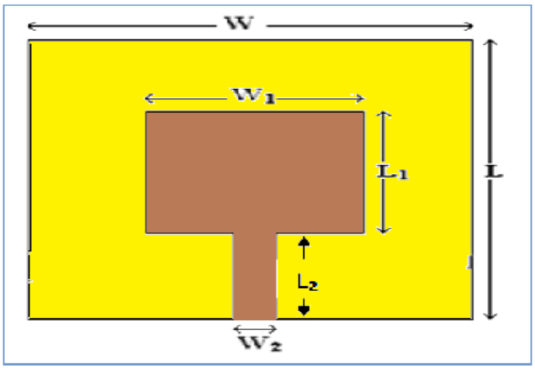

Fig.1 Geometry of the designed antenna

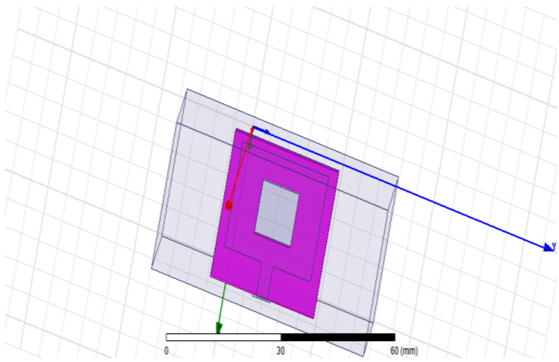

Fig.2 Actual HFSS design

To provide the hybrid structure to the antenna structure an additional rectangular cavity is introduced between the original duroid substrate. The different characteristics of the antenna such as return loss, gain, bandwidth, directivity, radiated field and VSWR is analysed for this designed antenna. It is observed that the gain of the designed antenna using hybrid substrates is high in comparison to conventional antenna. The antenna design is simulated using High frequency structure simulator software.

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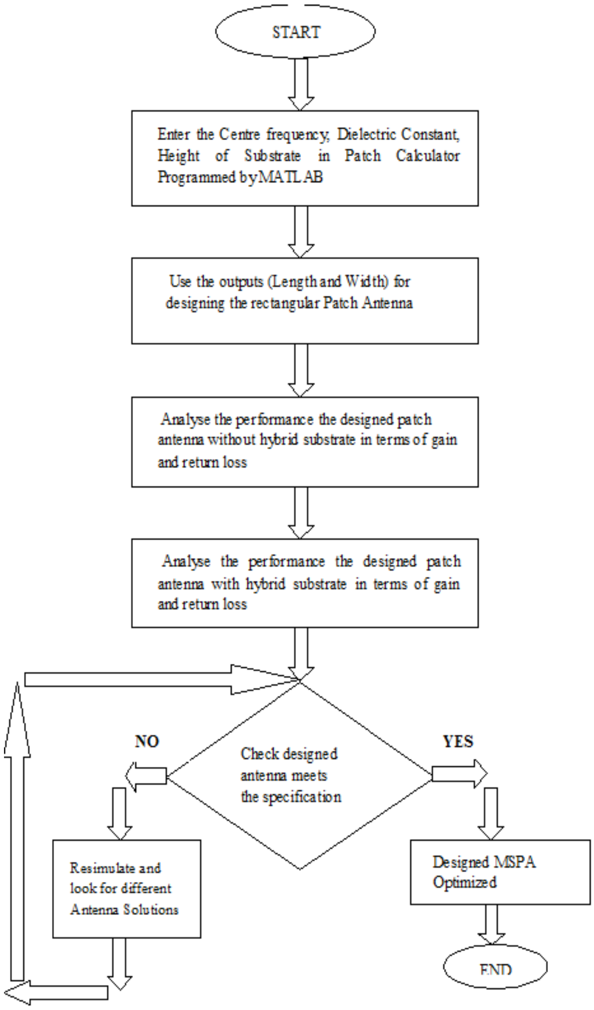

Fig.3 Flow chart for the designed antenna

III. RESULTS AND DISCUSSION

The designed microstrip wide band rectangular patch antenna is simulated by using the software HFSS (High Frequency Structure simulator). The simulated results for return loss, antenna gain, VSWR, directivity, electric field are observed for the different hybrid substrate materials such as benzocyclobuten, Rogers TMM3, Arlon AD250, and Polyquartz. All the outputs of the designed antenna using hybrid substrates and conventional substrates is shown below-

A. *Outputs using Conventional antenna*

As the designed frequency is 5 GHz and dielectric constant for duroid is 2.2 .The return loss, gain, directivity and voltage standing wave ratio curve using conventional substrate is given below.

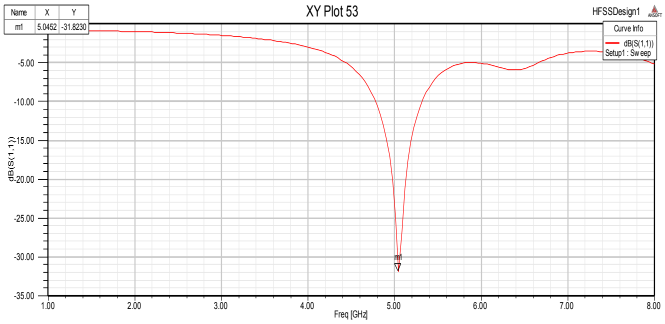

Fig.4 Return loss Vs Frequency

From the Fig.4 it is seen that the return loss is -31.82 dB in the conventional substrate.

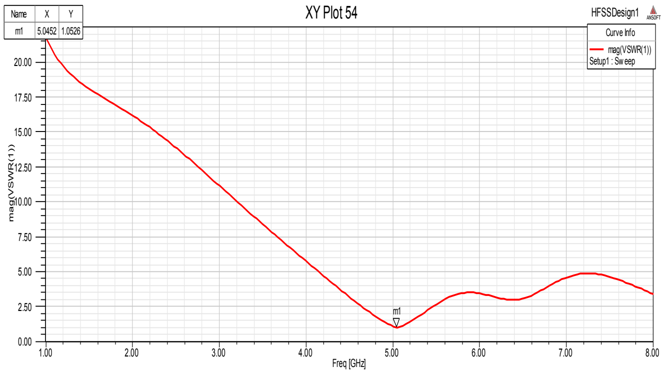

Fig.5 Voltage Standing Wave Ratio

From the above figure it is seen that VSWR is 1.0526.

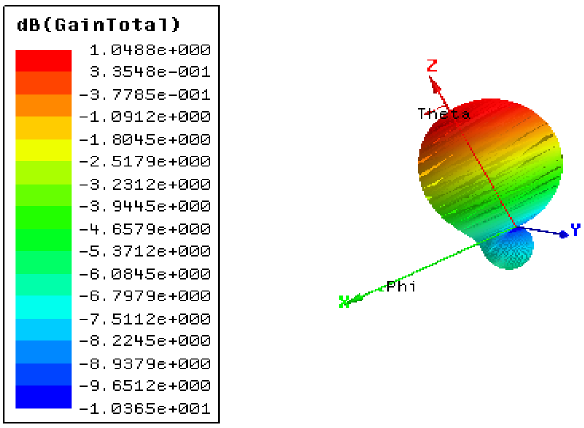

Fig.6 Gain of the Antenna

From the above 3-D polar plot it is seen that the maximum gain of 1.04 dB is achieved with conventional antenna.

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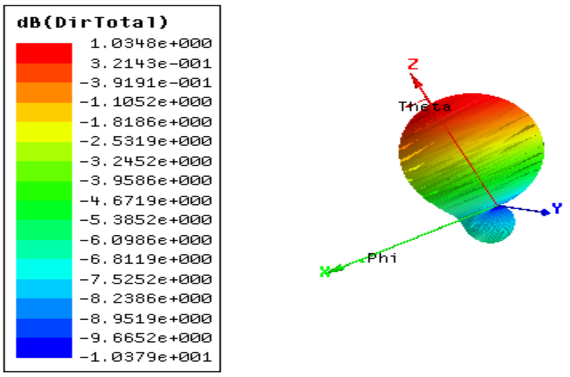

Fig.7 Directivity of the Antenna

The maximum directivity of the antenna is. So antenna has good directional properties.

Outputs using hybrid substrates

A. Outputs using benzocyclobuten

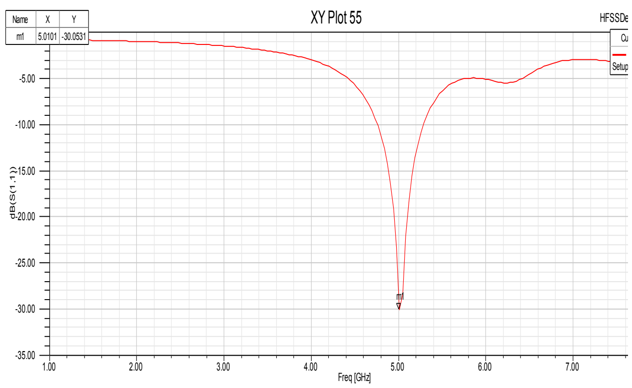

Fig.8 Return loss Vs Frequency

From the Fig.8 it is seen that received return loss < -10dB.The minimum return loss is -30.05dB is received when benzocyclobuten is used for hybrid structure.

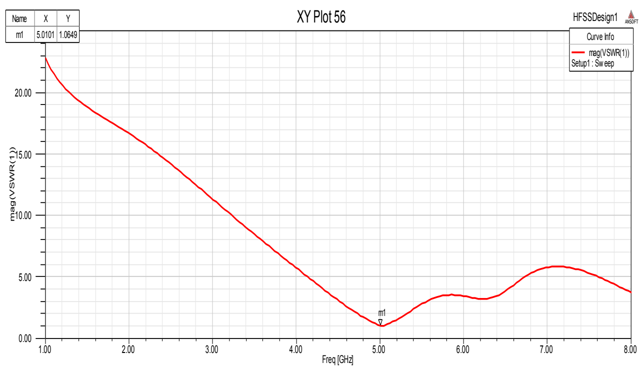

Fig.9 Voltage Standing Wave Ratio

From the above figure it is seen that VSWR is less than 2 and it is 1.0649.

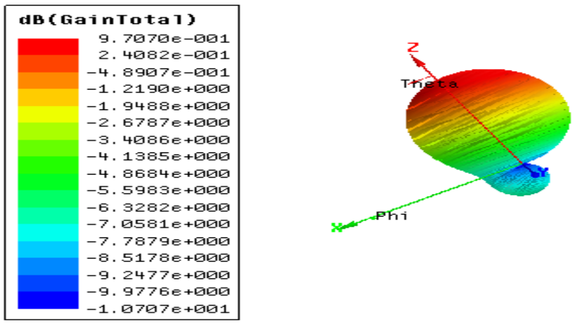

Fig.10 Gain of the Antenna

From the above 3-D polar plot it is seen that the maximum gain of 9.70 dB is achieved when benzocycloubuten is taken as hybrid material.

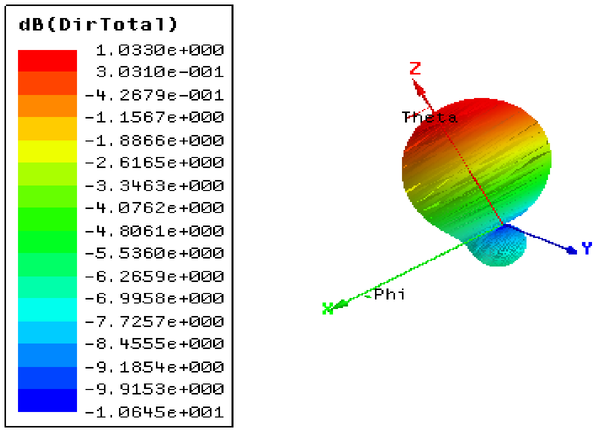

Fig.11 Directivity of the Antenna

The maximum directivity of the antenna is 1.03dB is achieved when benzocyclobuten is taken as hybrid material.

B. Outputs using Rogers TMM3

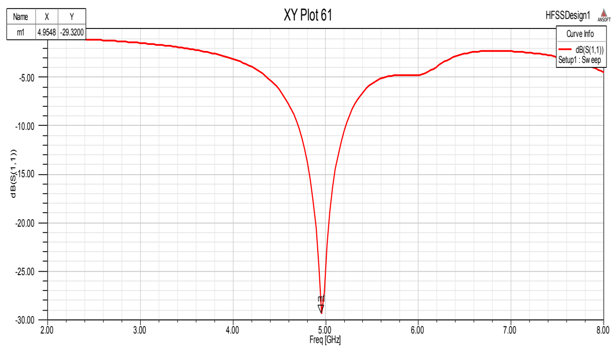

Fig.12 Return loss Vs Frequency

A minimum return loss of -29.32dB is achieved when Rogers TMM3 is used to provide hybrid structure.

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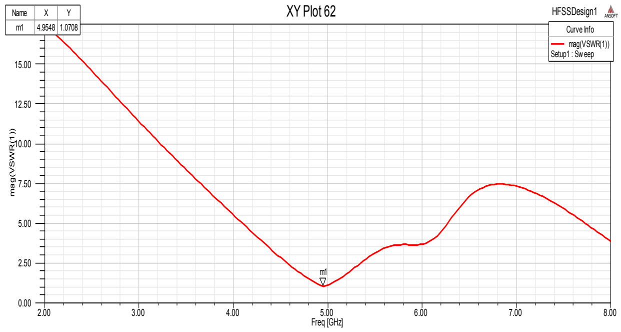

Fig.13 Voltage Standing Wave Ratio

VSWR of the antenna is 1.07 or less than 2.

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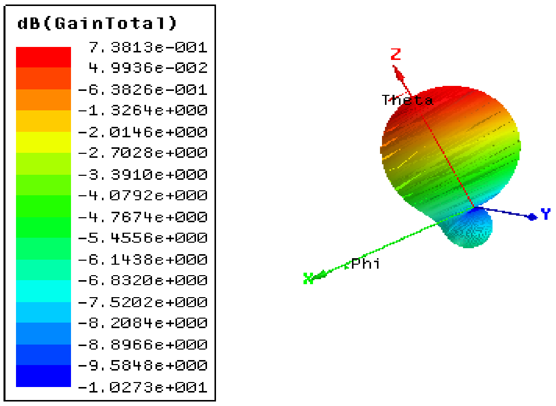

Fig.14 Gain of the Antenna

From the above 3-D polar plot it is seen that the maximum gain of 7.38 dB is achieved when Rogers TMM3 is taken as hybrid material.

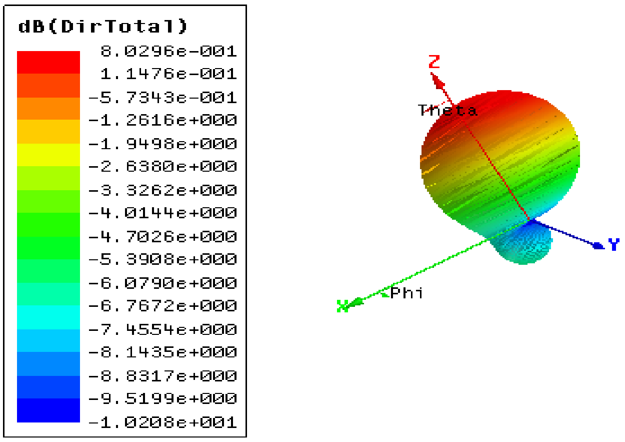

Fig.15 Directivity of the Antenna

The maximum directivity of the antenna is 1.03dB

C. *Outputs using Arlon AD250*

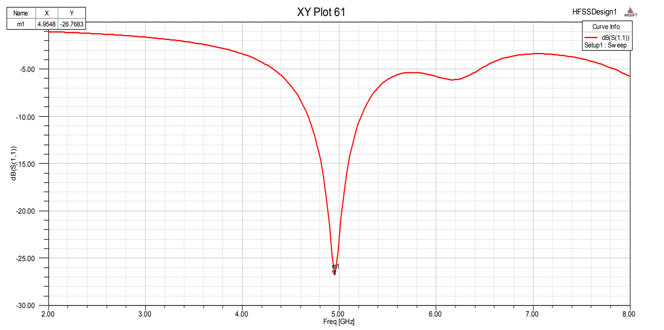

Fig.16 Return loss Vs Frequency

The minimum return loss of the antenna is -26.76dB is achieved when arlon AD250 is taken as hybrid material.

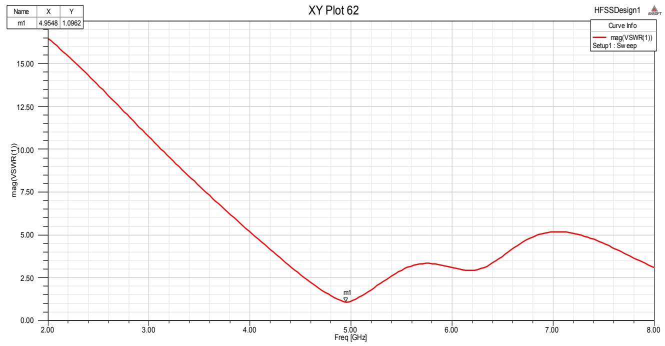

Fig.17 Voltage Standing Wave Ratio

From the Fig.17 it is seen that VSWR is less than 2 and it is 1.09.

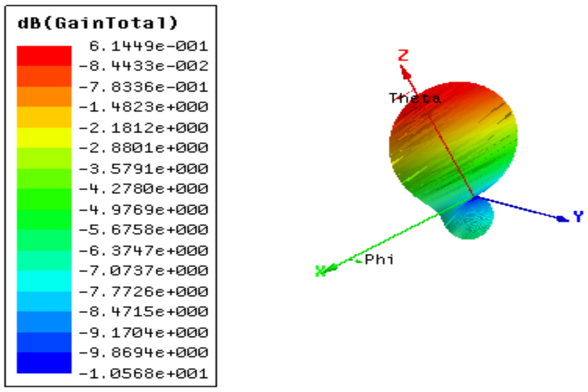

Fig.18 Gain of the Antenna

From the above 3-D polar plot it is seen that the maximum gain of 6.14 dB is achieved when Arlon AD250 is taken as hybrid material.

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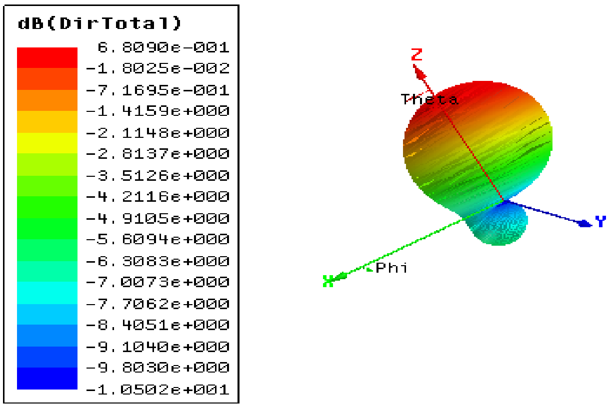

Fig.19 Directivity of the Antenna

D. *Outputs using Poly Quartz*

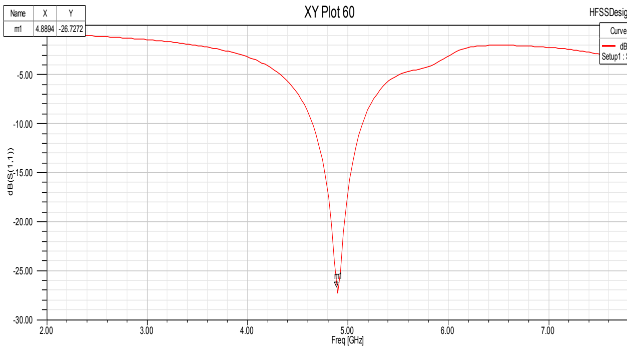

Fig.20 Return loss Vs Frequency

A minimum return loss of -26.72 dB is achieved when poly quartz is used to provide hybrid structure.

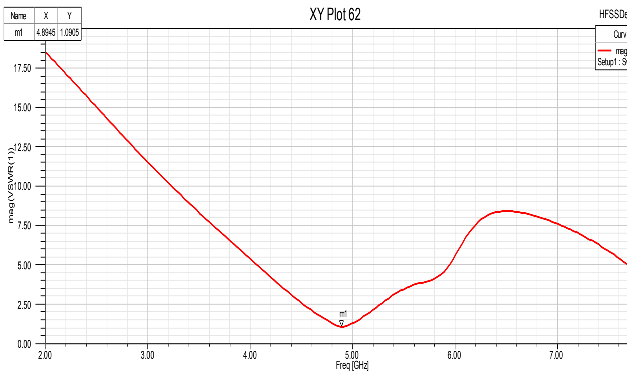

Fig.21 Voltage Standing Wave Ratio

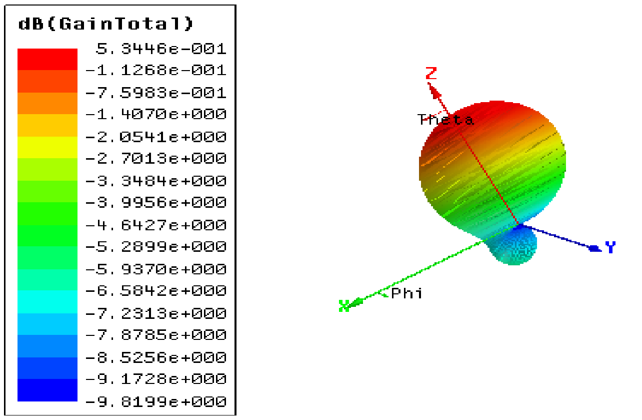

Fig.22 Gain of the Antenna

From the above 3-D polar plot it is seen that the maximum gain of 5.34dB is achieved when polyquartz is taken as hybrid material.

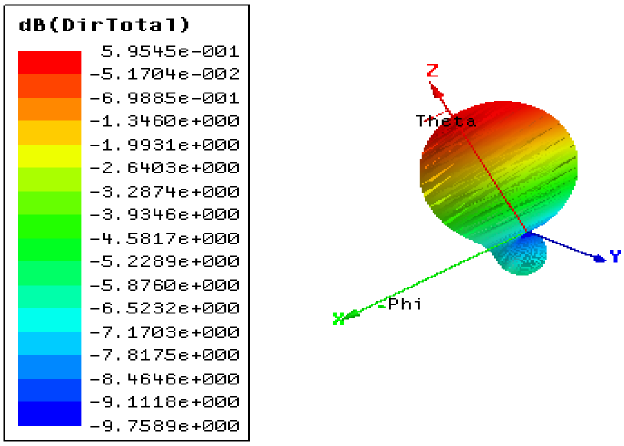

Fig.23 Directivity of the Antenna

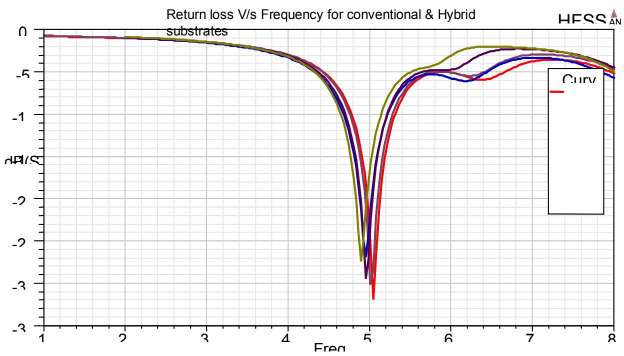

Fig.24 Return loss V/s Frequency for hybrid and Conventional substrates

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Fig.24 shows the return loss V/s frequency for the hybrid and the conventional substrate.

TABLE I

COMPARISON CHART OF HYBRID AND NON HYBRID STRUCTURE USING DIFFERENT MATERIALS

	Hybrid material	Minimum Return Loss(dB)	VSWR	Max. Gain(dB)	Directivity(dB)
Without hybrid structure	No material	-31.82	1.052	1.04	1.03
With Hybrid structure	Benzocyclobuten	-30.05	1.06	**9.70**	5.03
	Rogers TMM3	-29.32	1.07	7.38	8.029
	Arlon AD250	-26.76	1.09	6.14	6.80
	Poly Quartz	-26.72	1.09	5.34	5.95

IV. RESULTS AND DISCUSSION

So the designed rectangular microstrip antenna using hybrid substrate has the high gain characteristics than the conventional antenna. The designed antenna is analyzed for the different characteristics such as gain, return loss, directivity and voltage standing wave ratio etc. It is observed that the benzocyclobuten provides the maximum gain of 9.70dB for the frequency of 5 GHz. Minimum return loss is -30.05 dB. For the different hybrid materials antenna gain is increased significantly that is shown in table I

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