

## **A Microstrip Dipole Patch Antenna Design for SAR Reduction**

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**Abstract-** In this paper A Microstrip Dipole Patch antenna designed above an EBG substrate at the 3.5-GHz band for application of 4G wireless communications systems. One of the motivations for this proposal is that the size of the EBG substrate can be small enough for a handset with reduced SAR. In The Proposed model the value of the averaged SAR over 10 g was reduced to 0.359141 W/kg at the center frequency 1.6GHz. The SAR for the proposed Micro strip Dipole Patch antenna with the EBG structure is 42% lower than that the reference dipole antenna model. The radiation efficiency is also improved with the minimum VSWR. The design tool used for antenna simulation is CST (Computer Simulation Technology) software.

**Keywords:** - Electromagnetic band-gap (EBG) structure, Handset antenna, Specific absorption rate (SAR).

### **INTRODUCTION**

With the rapid growth in the use of mobile handsets the electromagnetic radiation from the mobile phones is increasing day by day and it's affecting to the human head. The specific absorption rate (SAR) is a defined measure to evaluate the power absorbed by biological tissue. The specific absorption rate (SAR), defined as:-

$$SAR = \frac{\sigma E^2}{\rho} = c \frac{dT}{dt}$$

is equivalent to the tissue heating rate, where the symbols  $\sigma$  for electrical conductivity,  $\rho$  for mass density,  $c$  for specific absorption rate and  $dT/dt$  for the changing rate of the temperature in body tissue have their typical meanings. Recent radiation protection standards specify threshold values for averaged SAR averaged over tissue masses of 1 or 10 gm, respectively, which should not be exceeded by any cellular mobile phone apparatus. The safety guidelines for EM wave exposures have been established by international standardization bodies [2], [3]. The SAR value is influenced by various Antenna parameters such as antenna positions relative to the human body, radiation patterns of the antenna, radiated power. The SAR in life tissue can be reduced by reducing the power radiated by the mobile antenna toward the human head. Lots of work is going on to find out the different ways to reduce radiation toward human life tissues. Some of the initial work suggested the use of RF shields, which is not a convenient solution for mobile applications. Some studies inserted a reflector between the radiator and the head [4]. But as the reflectors are good conducting surfaces; they reverse the phase of impinging electromagnetic waves. Due to that, an antenna needs to be placed at the distance one-quarter wavelength ( $\lambda/4$ ) from the reflector to ensure the constructive interference between the incident and reflected

waves. Another disadvantage of metallic sheets is supporting surface waves. This fact disallows the realization of antennas with a very low profile. Another study applied a ferrite sheet to reduce the magnetic field around the antenna [5].

In wireless technology, the profile of the radiated energy beam depends on antenna properties. Due to this fact, a specified radiation pattern of the antenna is required for most cases. In order to improve the antenna performance, a novel breakthrough based on so-called metamaterials emerged in the last two decades [6], [7]. Meta materials are a kind of a material with electromagnetic properties not found in nature. Recent studies suggest the use of electromagnetic band-gap (EBG) substrate for reduction of SAR [1], [8]. Most of the energy emitted by an antenna is formed into surface waves and leads to distorted radiation pattern and very poor front-to back ratio. EBGs represent a promising way to overcome some of these problems and to make possible to design e.g. high-gain, compact antenna arrays with the desired radiation properties in a relatively simple way [9], [10]. SAR can be decreased by reducing the back-radiation coming from the antenna and the ground plane[11], the substrate materials and its dielectric properties also plays important role in SAR reduction[12].

## II MODEL AND METHOD

### A. PROPOSED DIPOLE PATCH ANTENNA

A Dipole Patch Antenna above an EBG substrate was examined. Fig. 1,2,3 & 4 illustrates the geometry of the antenna in proximity to a simplified head model. The dipole patch dimension is  $L=45\text{mm}$ ,  $W=45\text{mm}$  & Thickness is  $0.1\text{mm}$ . The center frequency is  $1.65\text{GHz}$  & the total frequency Range from  $0.9\text{GHz}$  to  $3.5\text{GHz}$  taken.

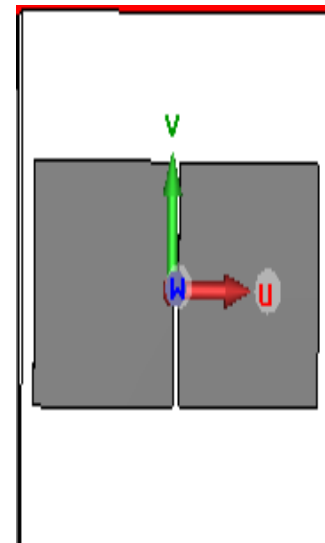
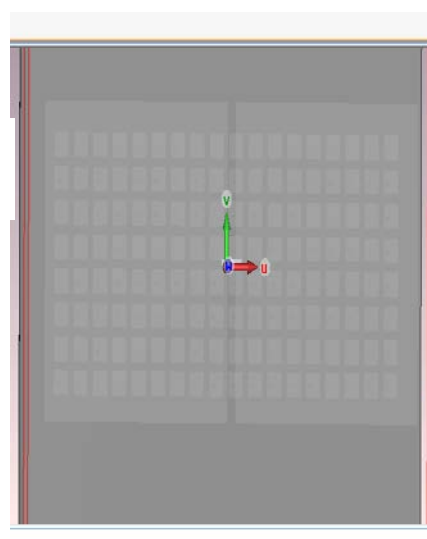
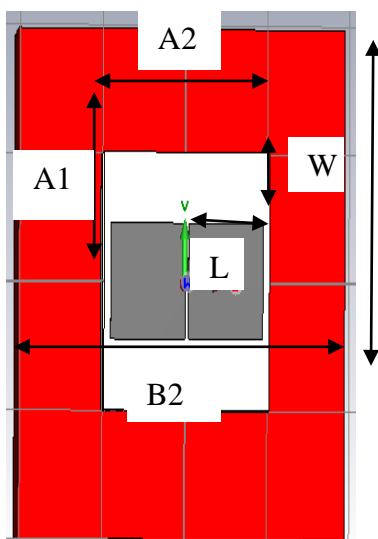


Fig. (1) Proposed Antenna Model

Fig. (2) EBG Substrate

Fig. (3) Dipole Patch Antenna

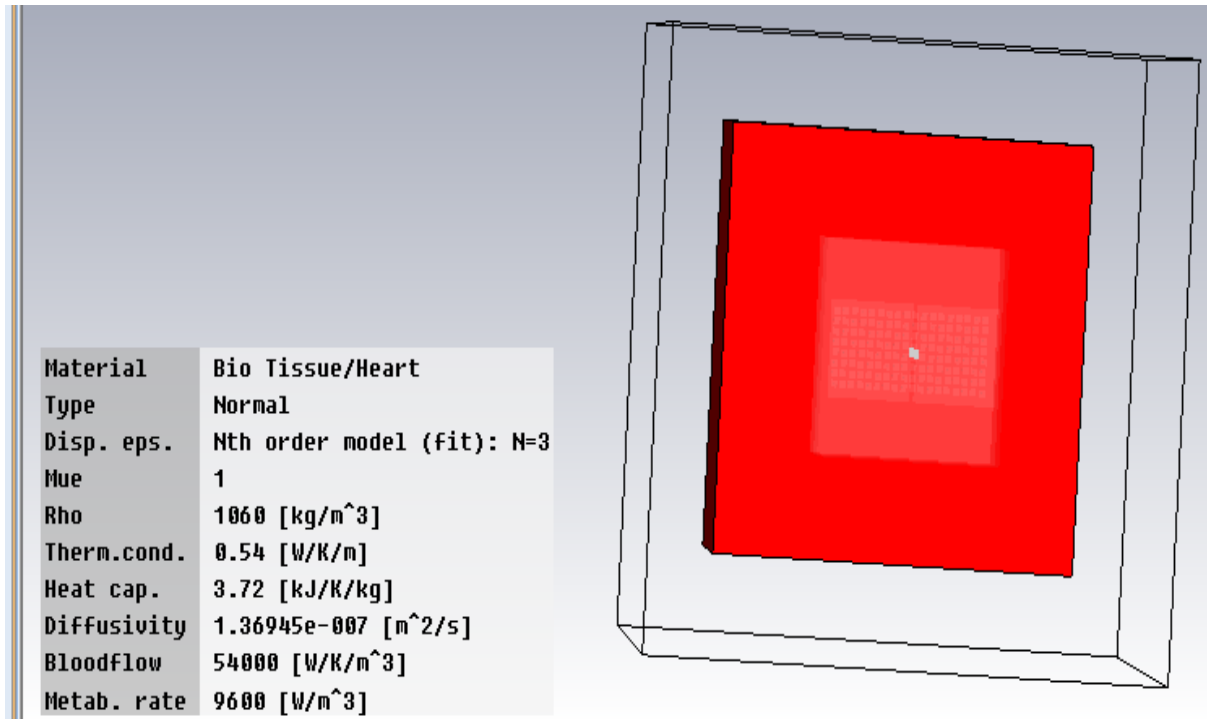


Fig. (4) Human Head model

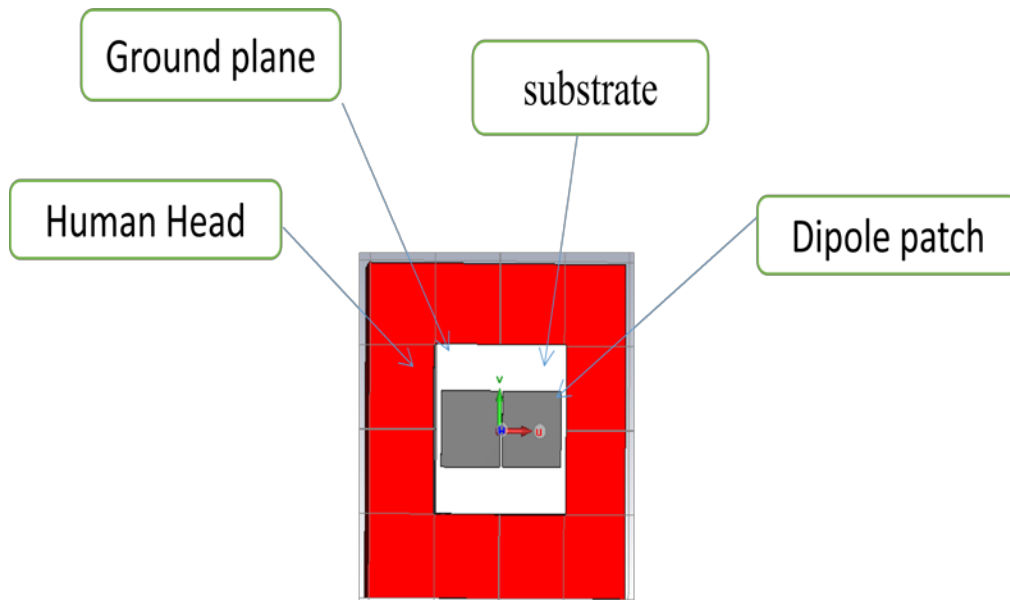


Fig. (5) Geometry of the proposed Dipole Patch Antenna above an EBG substrate.

A Rectangular shaped mushroom type EBG was considered. The dimensions of the EBG patch are set from the following formulas [15]:

$$L = \mu_0 h \tag{1}$$

$$C = \frac{W \epsilon_0 (1 + \epsilon_r)}{\pi} \cosh^{-1} \left( \frac{2W + g}{g} \right) \tag{2}$$

Where  $\mu_0$  is the permeability of free space and  $\epsilon_0$  is the permittivity of free space. From the equivalent inductance and capacitance obtained from (1) and (2), the approximate centre frequency of the band-gap is obtained. Use of the EBG substrate give better SAR and gain results as compared to that of PEC substrate[7],[16]. The Proposed structure has 144(18\*8) EBG Patches.

Table-1 Dimentions of the proposed model

Elements	Dimentions			Material used
Human Head	B1=200mm	B2=200mm	B3(Thikness) =70mm	Bio Tissue Heart
Ground Plane	A1=100mm	A2=100mm	A3(Thikness) =20.1mm	PEC
Substrate	C1=100mm	C2=100mm	C3(Thikness) =20mm	Rogers RT6010(lossy)
EBG patch	U= -33.60mm	V=-14.40mm	W= -0.1mm	PEC
Cylinder via	outer radius =0.1mm	Ucenter = -15.55mm	Vcenter = -5.95mm	PEC
Dipole Patch Antenna Arm-1	L=45mm	W=45mm	T(Thikness) =0.1mm	PEC
Dipole Patch Antenna Arm-2	L=45mm	W=45mm	T(Thikness) =0.1mm	PEC

B. COMPUTATIONAL METHODOLOGY

Computer Simulation Technology Microwave Studio (CST MWS) is used as a major simulation tool dependent on the finite-difference time-domain method (FDTD). An unvarying meshing scheme was chosen to make major computation which is devoted to make major computation which is devoted to homogeneous mark

boundaries for the fastest and faultless result. A fraction of the cubic human head model with dimensions of  $200 \times 200 \times 70 \text{ mm}^3$  is utilized for this analysis [16], [17]. The electrical constants of the muscle tissues and remaining details are taken from [18] and [19]. The antenna is operated in the frequency range of 0.9 –3.5GHz.

III COMPUTATIONAL RESULT

The proposed antenna model was simulated by CST (Computer system technology) software. Fig.5-Template Based Post processing SAR result, Fig.6- SAR Distribution over Human Head model, Fig.7- Voltage standing Wave Ratio ( VSWR) Plot, Fig.8- S-Parater [Magnitude in dB] vs Frquency / GHZ, Fig.9- Radiation pattern Theta (dBi). Summarised result is also in the table-2 & comparision with the reference model is in the table-3.

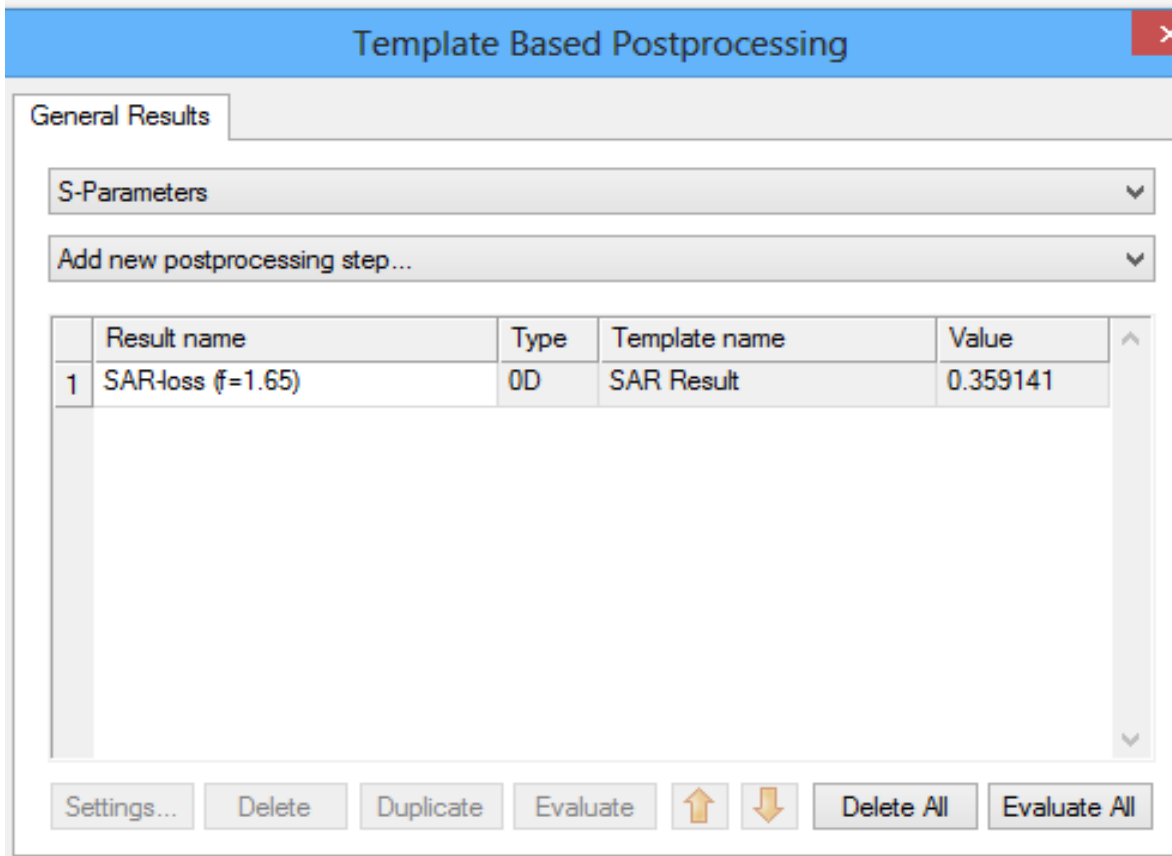


Fig. (6) Template Based Post processing SAR result

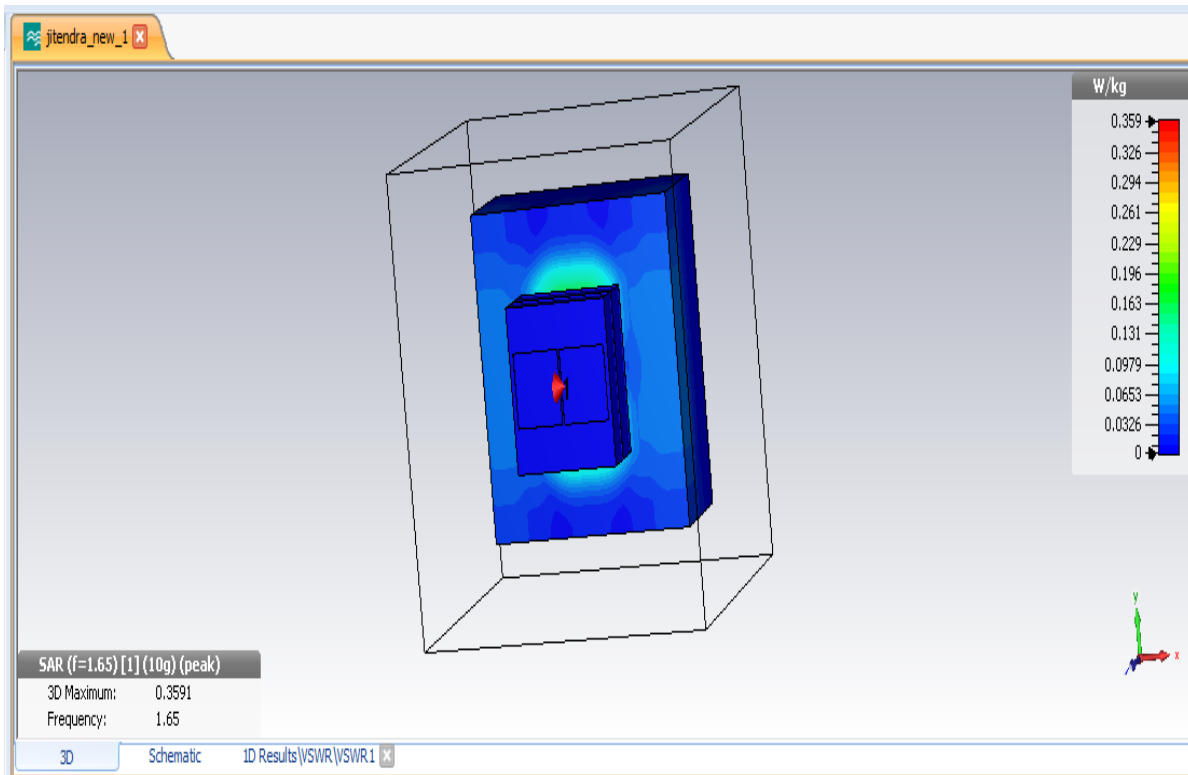


Fig. (7) - SAR Distribution over Human Head model

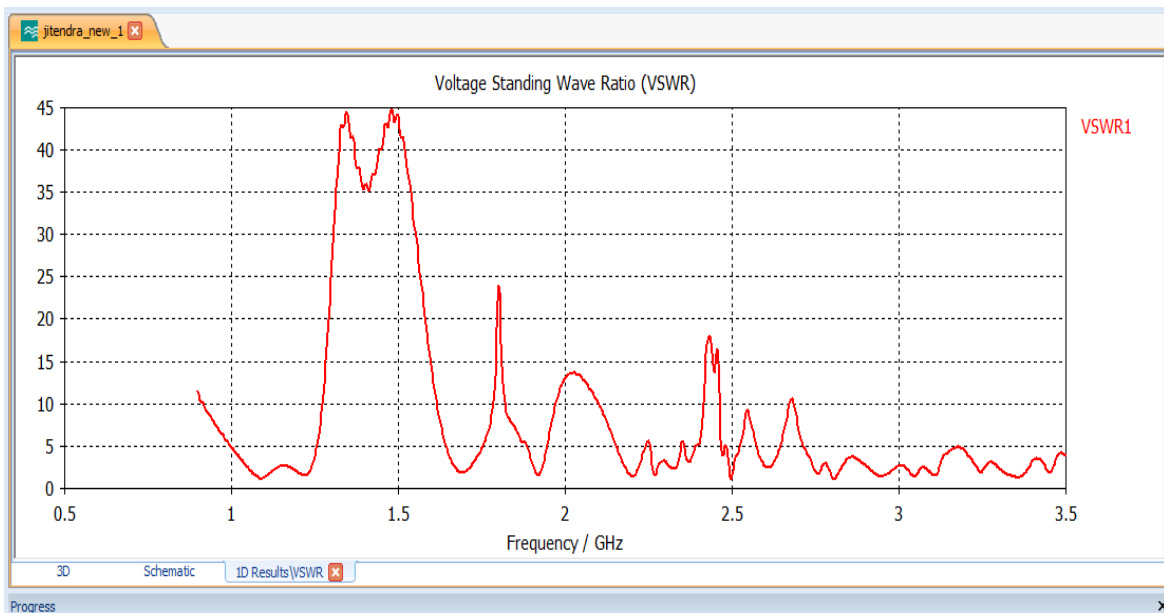


Fig.(8) - Voltage standing Wave Ratio ( VSWR) Plot

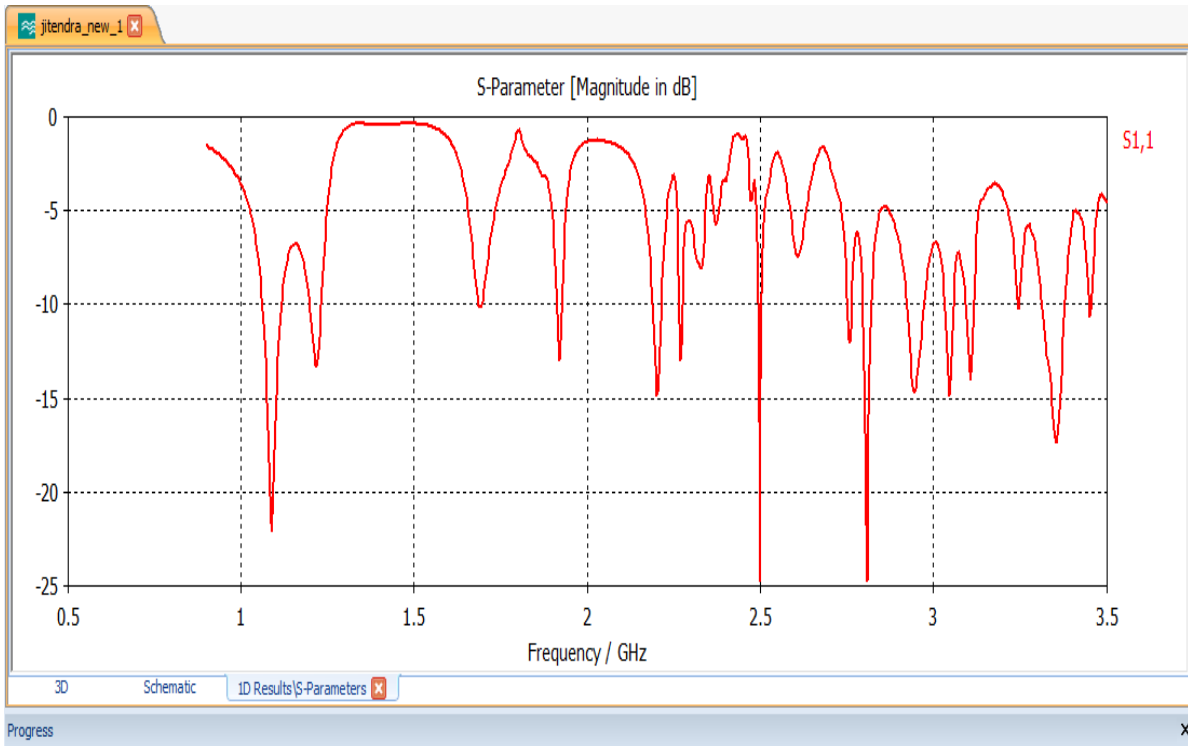


Fig. (9) - S-Parater [Magnitude in dB] vs Frquency / GHZ

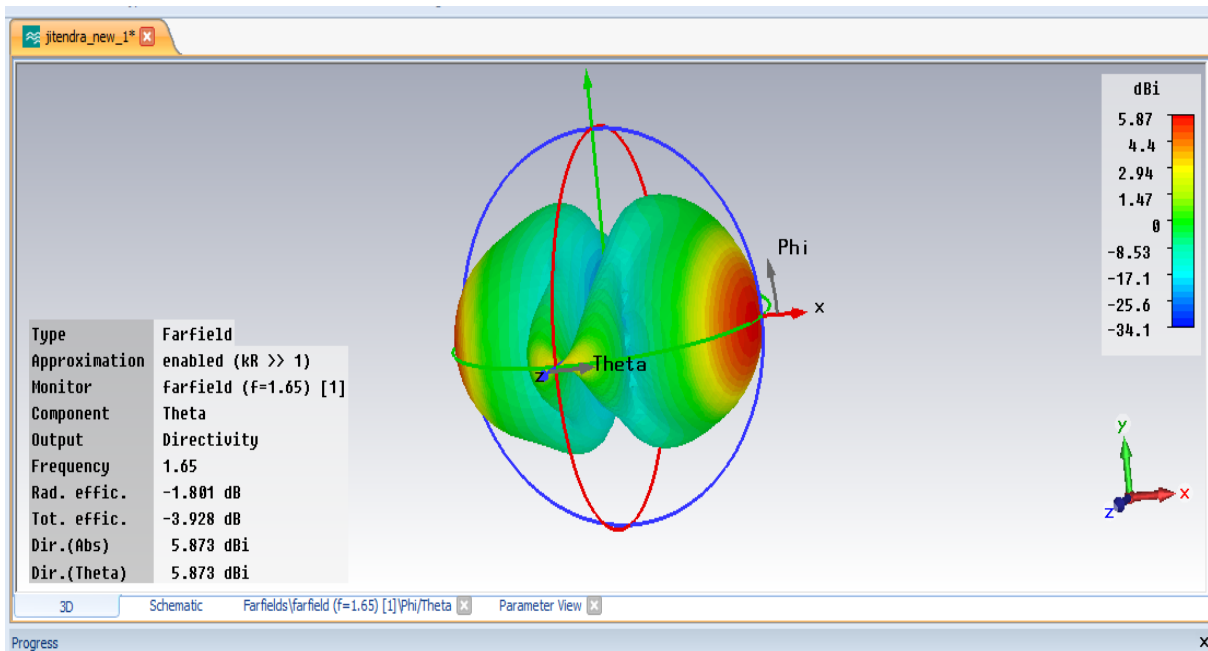


Fig. (10) - Radiation pattern Theta (dBi)

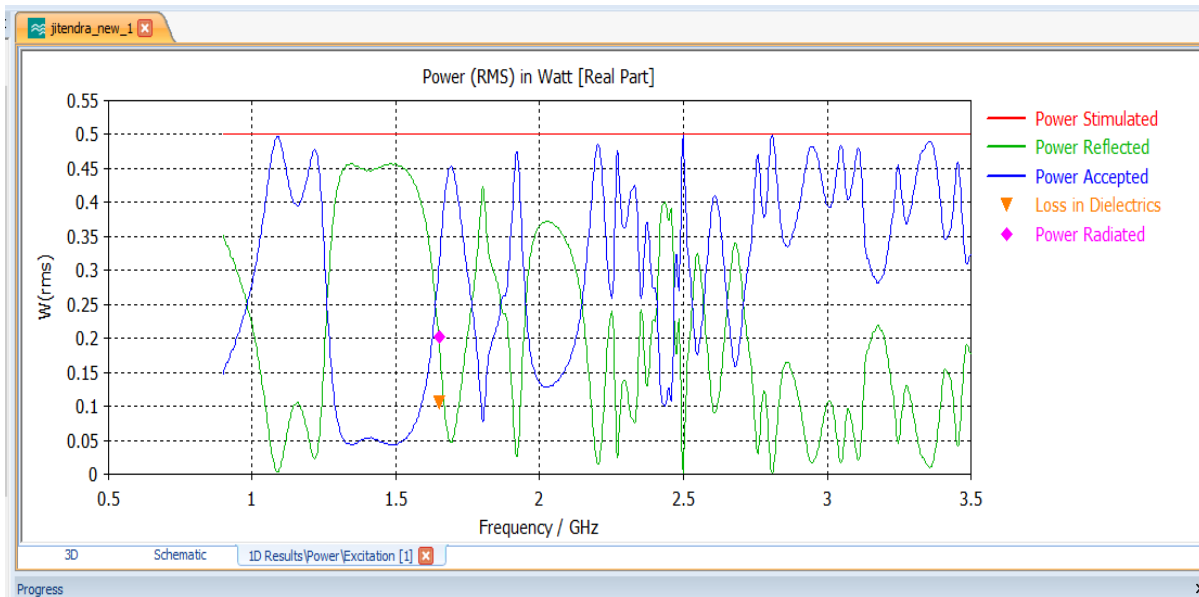


Fig. (11) Power stimulated, Reflected, Accepted, Dielectrics & Radiated

Fig.(6) shows Template Based Post processing SAR result, Fig.(7) SAR Distribution over Human Head model, Fig.(8) Voltage standing Wave Ratio ( VSWR) Plot, Fig.(9) S-Parater [Magnitude in dB] vs Frquency / GHZ, Fig.(10) Radiation pattern Theta (dBi), Fig. (11) Power stimulated, Reflected, Accepted, Dielectrics & Radiated.

**SIMULATION RESULTS AT 1.65GHZ CENTER FREQUENCY & FREQUENCY BAND 0.5-3.5GHZ:-**

Table-2 Simulation Results at 1.65GHz Center Frequency

Parameters	Result obtained at center frequency 1.65GHz
Maximum SAR (rms,10g) [W/kg]	0.359141
VSWR	1.1     1.1 (at 2.5 GHz) & 3.7 (at 1.65 GHz)
S11	-24.73 dB (at 2.5 GHz) & -5dB (at 1.65 GHz)
Radiation Efficiency	66%
Gain	4.072 dB
Directivity	5.873 dBi



Table-3 Comparison of SAR &amp; Return loss Results

Parameters	Existing Dipole antenna above EBG [1]	Existing Ddipole antenna above PEC [1]	Proposed Dipole patch antenna above EBG
Maximum SAR (rms,10g) [W/kg]	0.84 W/kg	5.15 W/kg	0.359 W/kg (at 1.65GHz)
Return loss	-14dB	-3.0dB	-24.73dB

#### IV CONCLUSION

In The Proposed model The value of the averaged SAR over 10 g was reduced to 0.359141 W/kg at the center frequency 1.6 GHz. The SAR for the proposed Microstrip Dipole Patch antenna with the EBG structure was 42% lower than that the reference dipole antenna model. In the reference model the peak value of the averaged SAR over 10 g was 5.15 W/kg for the Dipole antenna over the PEC substrate and The value of the averaged SAR over 10 g was 0.84 W/kg for the Dipole antenna over the EBG substrate [1]. The Return loss for the New Microstrip Dipole Patch antenna with the EBG structure was -24.73dB at 2.5 GHz and VSWR was minimum that is 1.123 at 2.5 GHz.

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