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A MICROSTRIP DIPOLE PATCH ANTENNA DESIGN FOR SAR REDUCTION

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ABSTRACT:- In this paper a Microstrip Dipole Patch antenna above an EBG substrate was investigated at the 1-5GHz frequency range for potential application as a handset antenna 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 0.11142W/kg at the centre frequency 3.5GHz. The SAR for the proposed Microstrip Dipole Patch antenna with the EBG structure was 72% lower than that the reference dipole antenna model. The radiation efficiency was 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).

I. INTRODUCTION

With the rapid growth in the use of mobile handsets the electromagnetic radiation from the mobile phones is increasing day by day and its 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 σ for electrical conductivity, ρ 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 towards 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 (λ/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 Microstrip 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=45mm , W=45mm & Thickness is 0.1mm. The centre frequency is 3.5GHz & the total frequency Range from 1 GHz to 5 GHz taken.

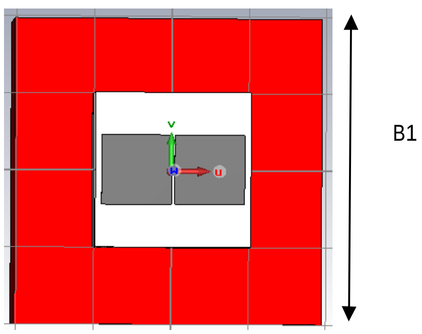

Fig.(1) Proposed Antenna Model

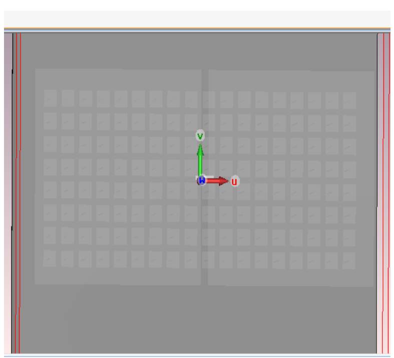

Fig.(2) EBG Substrate

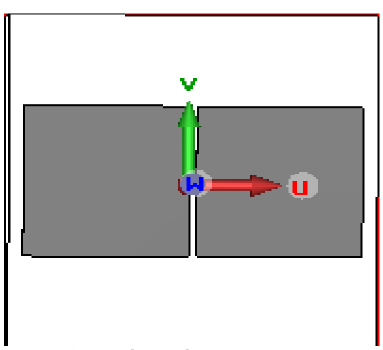

Fig.(3)Dipole Patch Antenna

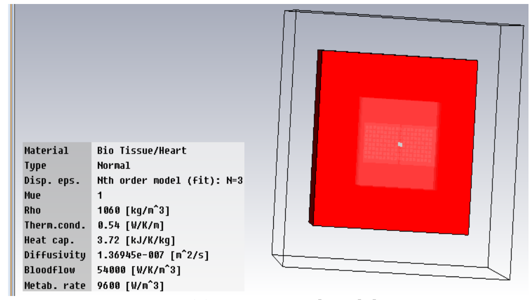

Fig.(4) Human Head model

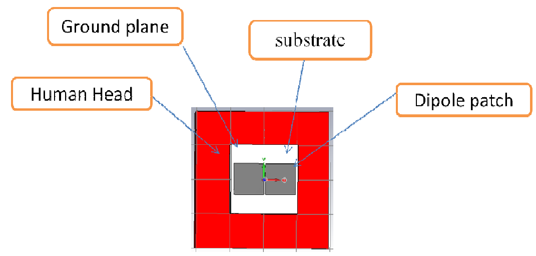

Fig.(5) Geometry of the proposed Dipole Patch Antenna above an EBG substrate.

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

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

$$C = \frac{W\varepsilon_0(1+\varepsilon_r)}{\pi}\cosh^{-1}\left(\frac{2W+g}{g}\right) \tag{2}$$

Where μ_0 is the permeability of free space and ϵ_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=200 mm	B2=200 mm	B3(Thikness) =70mm	Bio Tissue Heart
Ground Plane	A1=100 mm	A2=100 mm	A3(Thikness) =20.1mm	PEC
Substrate	C1=100 mm	C2=100 mm	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 × 200 × 70 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 1 – 5GHz.

III. COMPUTATIONAL RESULT

The proposed antenna model was simulated by CST (Computer system technology) software. Fig.6- SAR Distribution over Human Head model, Fig.7- Voltage standing Wave Ratio (VSWR) Plot, Fig.8- S-Parameter [Magnitude in dB] vs Frequency / GHZ, Fig.9- Radiation pattern Theta (dBi) & Fig.10- Power stimulated, Reflected, Accepted, Dielctrics & Radiated . Summarised result is in the table-2.

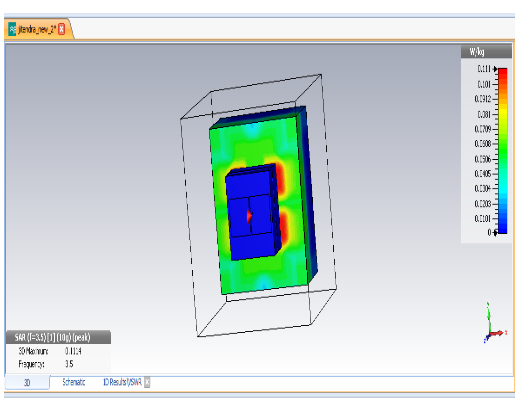

Fig.(6) - SAR Distribution over Human Head model

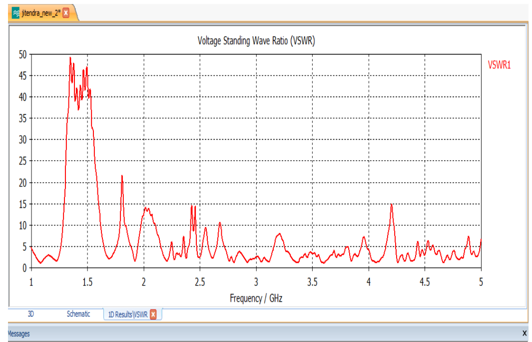

Fig.(7) - Voltage standing Wave Ratio (VSWR) Plot

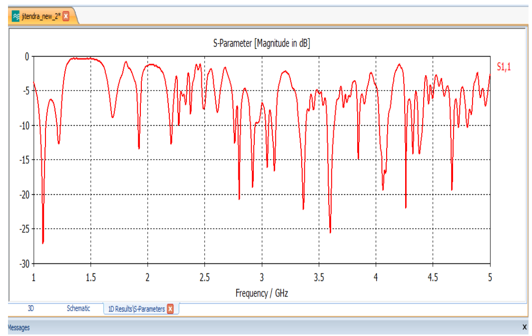

Fig.(8) - S-Parater [Magnitude in dB] vs Frquency / GHZ

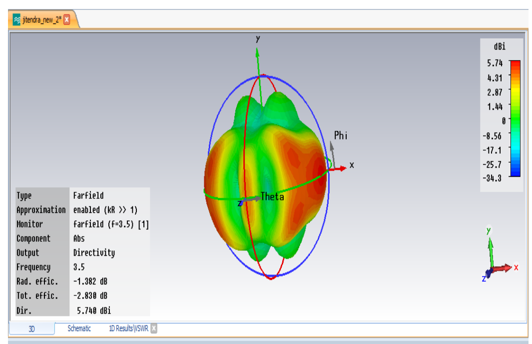

Fig.(9) - Radiation pattern Theta (dBi)

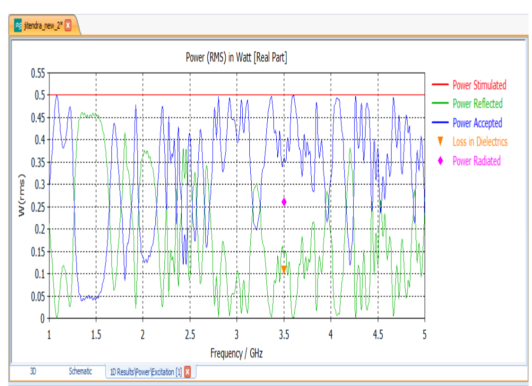

Fig. (10) Power stimulated, Reflected, Accepted, Dielctrics & Radiated

SIMULATION RESULTS AT 3.5GHZ CENTER FREQUENCY & FREQUENCY BAND 1- 3.5GHZ:-

Table-2 The results of proposed model at the centre frequency 3.5GHz

Parameters	**Result obtained at centre frequency 3.5GHz**
Maximum SAR (rms,10g) [W/kg]	0.11142
VSWR	1 (at 1.08 GHz), 1.2(at 4 GHz), 3.2 (at 3.5GHz)
S11	-27.09 dB (at 1.08GHz), -25.26 dB(at 3.6 GHz) & -5.4 dB(at 3.5 GHz)
Radiation Efficiency	73%
Total Efficiency	52%
Gain	4.358 dB
Directivity	5.74 dBi

IV. CONCLUSION

In the proposed model the value of the averaged SAR over 10 g was reduced to 0.11142W/kg at the centre frequency 3.5 GHz. The SAR for the proposed Microstrip Dipole Patch antenna with the EBG structure was 72% 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 (S_{11}) for the Proposed Microstrip Dipole Patch antenna with the EBG structure was -27.09 dB (at 1.08GHz), -25.26 dB(at 3.6 GHz) ,& -5.4 dB(at 3.5 GHz)at 3.5 GHz and VSWR was minimum that is 1 (at 1.08 GHz), 1.2(at 4 GHz), 3.2 (at 3.5GHz).

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