Design of Compact CBCPW fed Monopole Antenna ECG monitoring Applications

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Abstract : The novel approach of split-ring resonator loaded compact conductor backed fed monopole antenna designed for healthcare applications. The most important parameter of the proposed design has standard bandwidth, impedance matching, and low fabrication cost. The designed antenna works over a frequency from 2.36 to 2.48 GHz and 3.3 to 3.6 GHz. The simulated parameter values of the return loss, bandwidth, and field pattern are more suitable for medical communication.

***Keywords* - CB-CPW, ECG, antenna parameter, medical-bands, biocompatibility.**

1 INTRODUCTION

The miniaturized MMIC’s and biocompatible antennas are a very essential element in the biomedical communication system. Day to day life peoples are suffered many health problems like covid 19, numinous, cardiovascular problems, etc. the recent year we are facing covid 19 pandemic as well as heart attacks [1]. The newly advanced microwave engineering and 5G technologies formulated the low-power, miniaturized; a low-cost medical device example SRR inserted CB-CPW fed antennas, also more essential for continuous patient healthcare or ECG signal monitoring by 24hours.

The conductor-backed coplanar strip feed also called grounded coplanar strip feed (CBCPW or GCPW fed). This GCPW structure almost similar to the microstrip feed line, but the microstrip fed antenna required a special arrangement for making an antenna for monopole applications. The CBCPW feed has a wide range of input impedance, so this parameter makes a wonderful application in the area of MMICs and RF MEMS device design with CBCPW fed. The given prototype model operated in an industrial scientific band (2.4-2.5) GHz (ISM) and 5G medical communication (3.3-3.5) GHz band; since this prototype easy to communicate between other wireless technology like Wi-Fi, WiMAX, and IoT links, as result can be easily transmitted signal with squat latency and high data speed [2],[3].

The metamaterial or artificial material with epsilon negative and mue negative concept first introduced by Jagadish Chandra Bose in India [4]. The initial mathematical model introduced by Victor Vesgalo in 1968. The first practical MM structure is known as split-ring resonator simply SRR introduced in 1999[5]. Now all the design is targeted to miniaturization, the metamaterial inserted antenna design makes the miniaturization, simultaneous enhancement of gain, and antenna bandwidth, these are few reasons that the SRR loaded antennas widely used to design for all the medical communication fields.

The protocol is categorized into three types, implantable-WBAN, on-body WBAN, and off-body WBAN network. The on-body medical communication nearly two meters in and around the human body. The diverse types of sensors are placed on the body used to transmit physiological or encrypted medical data into the PS. After that this data send to the access point layer-2. Inter-WBAN message send by tier-2, here the more number of accesses points communicated to personal server in tier-3 layer, shown in Fig.1.1 [8]. Moreover the new technologies easily prop up by a WBAN, and easily interfaced with IoT based medical devices for the 5G applications.

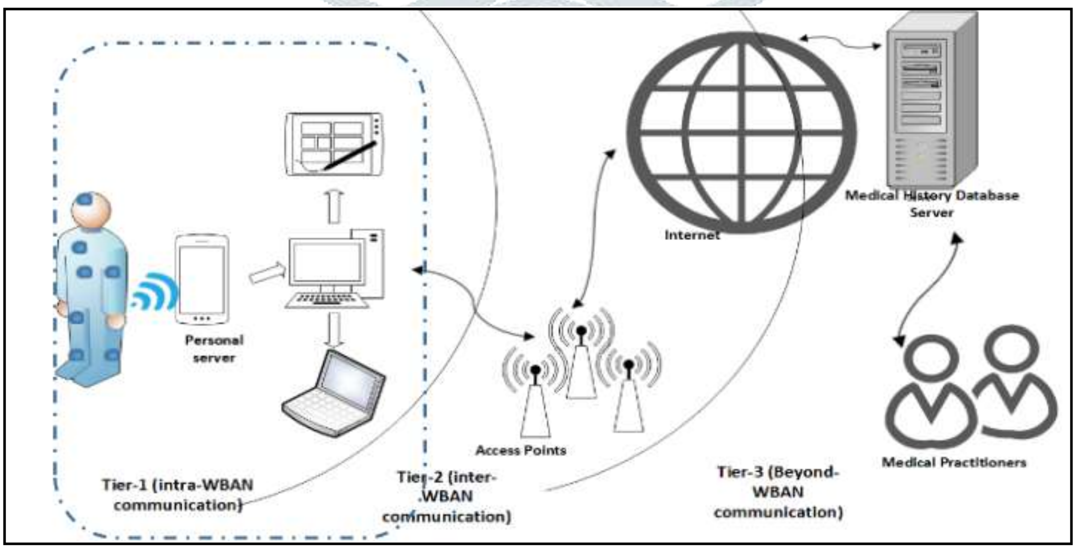

Fig.1.1 Communication between on-body and IoT [8].

The knowledgeable study, purpose, and motivation are expressed in part one. Part second described the internal description of the design. Part third focused on the result and discussion part. The reflection coefficients, VSWR, far-field plot are discussed. Part four is the conclusion of the HCDS PMA.

2 HCDS PMA DESIGN

The HCDS PMA structured parameters are computed based on the time domain solver approach. The Fig.2.1 pointed to the design steps of multilayered HCDS PMA. The pinnacle layer is called radiating patch, which converts RF electrical current to microwave or centimeter wave [6]. The next layer is called substrate, Teflon is the highly biocompatible dielectric substrate and cheapest among all other biocompatible dielectrics. The defected ground backed CPW fed with AMM loaded technique is a widely used method for miniaturization, also the simultaneously increasing the antenna directive gain and bandwidth. The skin, fat, muscles are bio tissues with the different dielectric constants are used to design a prototype for medical purposes. Fig.2.2 indicated the 3D-view of antenna design. The SRR lies in between radiator and bio-tissue. The SRR structures have circular rings and are separated by a small gap G; both have splits on the opposite sides S1 and S2 are shown in Fig.2.4. The electron movement on the first ring or upper ring is in the reverse path of the second ring; this makes the oscillation of electric and magnetic fields, which leads to the phenomena of -ve permeability and permittivity. The overall volume of HCDS PMA is 640mm^3, the length, width of HCDS PMA is 20mmx20mm, and thickness is 1.6mm. Fig.2.3 is the top view of HCDS PMA; the K indicated the breadth of the CPW ground plane, which is 9.2mm, Y indicated the CPW strip length is 10mm. Fig.2.4 focused on the rear view of HCDS PMA, R_1 and R_2 are the radii of the outer and inner ring of the SRR structure. The dimension of HCDS PMA has tabulated in Table.2.1. All the dimensions are mm-scale; moreover, these values are facilitated to ISM (2.4 to 2.5) GHz and 5G-MSB (3.4-3.6) GHz band based medical applications [9].

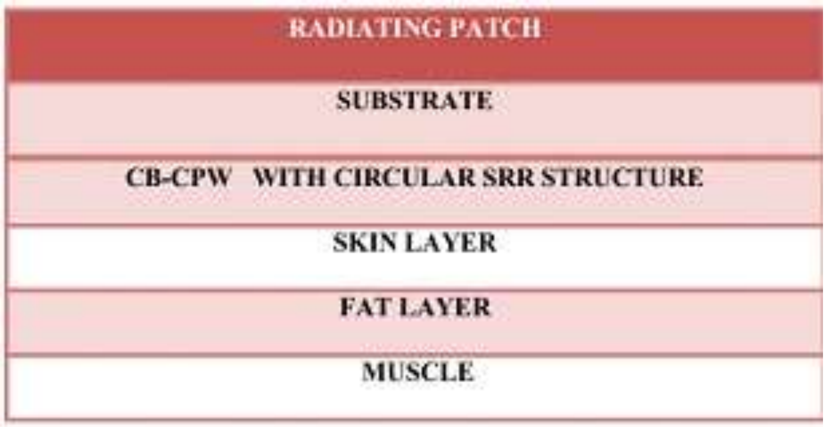

Fig.2.1Layered view: HCDS PMA.

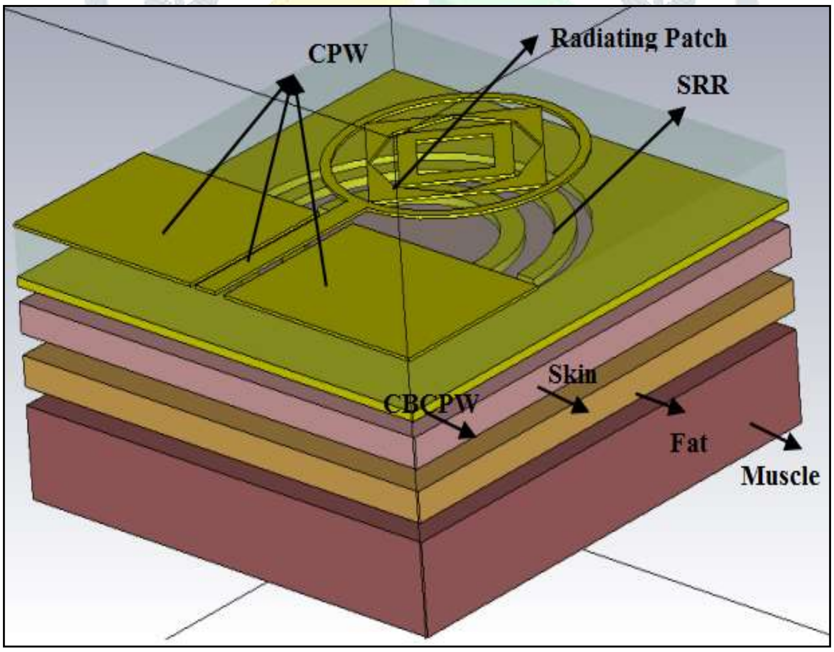

Fig.2.2 3D-view: HCDS PMA

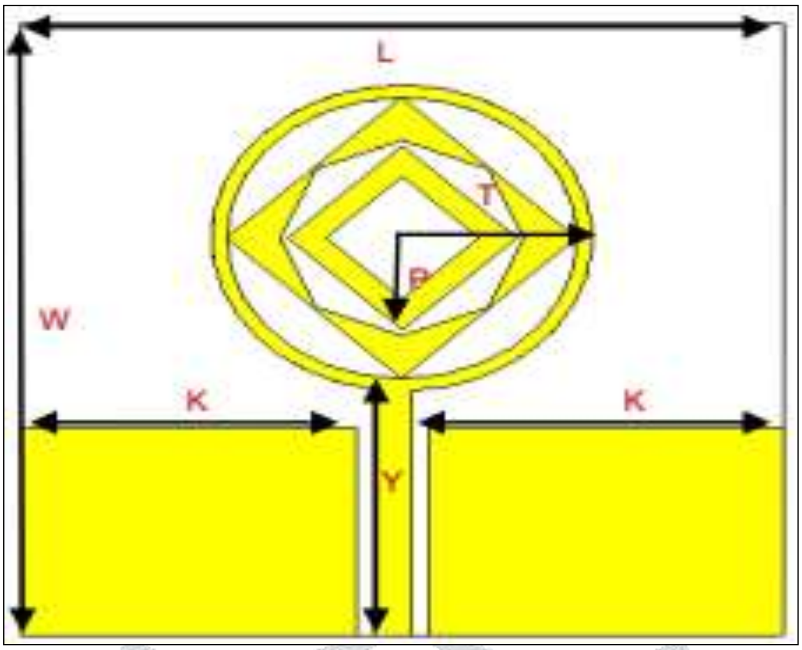

Fig.2.3 Top view of HCDS PMA

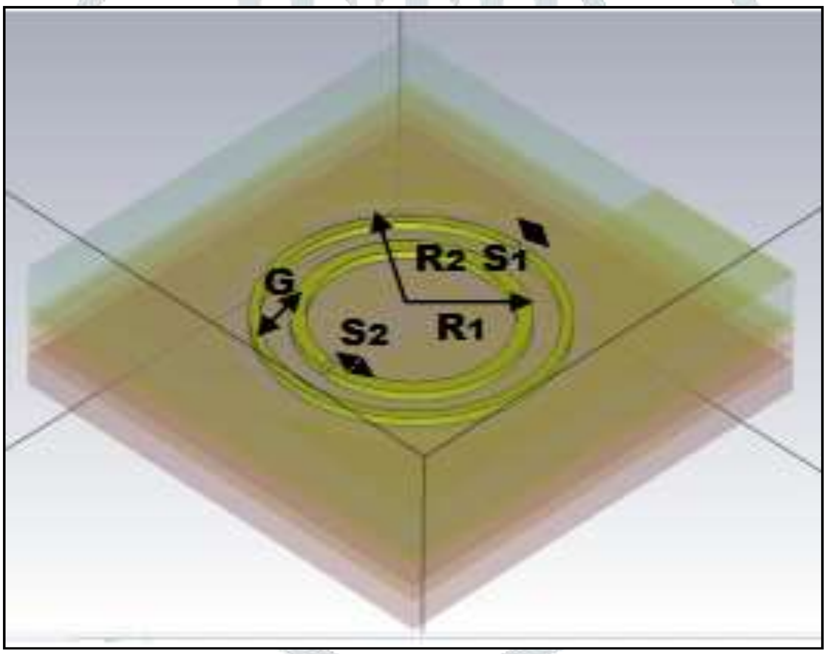

Fig.2.4 Back view of HCDS PMA

Table. 2.1 The dimensions for the HCDS PMA.

Parameter	(mm)	Parameter	(mm)
W	20	Y	10
L	20	R2	4.8
T	5.5	S1	0.5
K	9.2	S2	0.5
P	4.1	R1	6

3 RESULTS AND DISCUSSION

The HCDS PMA is computed by the time-domain solver method. The parameters of HCDS PMA are RL, E&H plane pattern also called principle pattern, impedance matching, or standing wave characteristics are plotted. We can calculate the antenna bandwidth from the RL or magnitude of the RC plot [6]. Antenna efficiency was calculated from the value gain and directivity. The scattering parameter of antenna measured by VNA and field strength of AUT measured through anechoic champers. The table.3.1 specifies the performance of the HCDS PMA and Referred PA.

3.1 RETURN LOSS AND VSWR

The reflection coefficient (RC) or return loss (RL) parameter indicated the power loss due to a mismatch of the antenna output port and free space. The negative twenty log of the modulus of S_{11} is called the RL of HCDS PMA [7]. The return loss value is positive but the refection coefficient is negative. The refection coefficient value of HCDS PMA are -18dB for free space,-30dB for skin,-16dB for fat at 2.45GHZ, and also -34dB for free space,-22dB for skin, -15dB for fat,-23dB for muscle at 3.5GHz are shown in Fig.3.1.Voltage standing wave ratio calculated from reflection coefficient. The minimum value of VSWR is 1.08 at 2.45GHz and 1.02 at 3.5GHz as exposed in Fig.3.2.

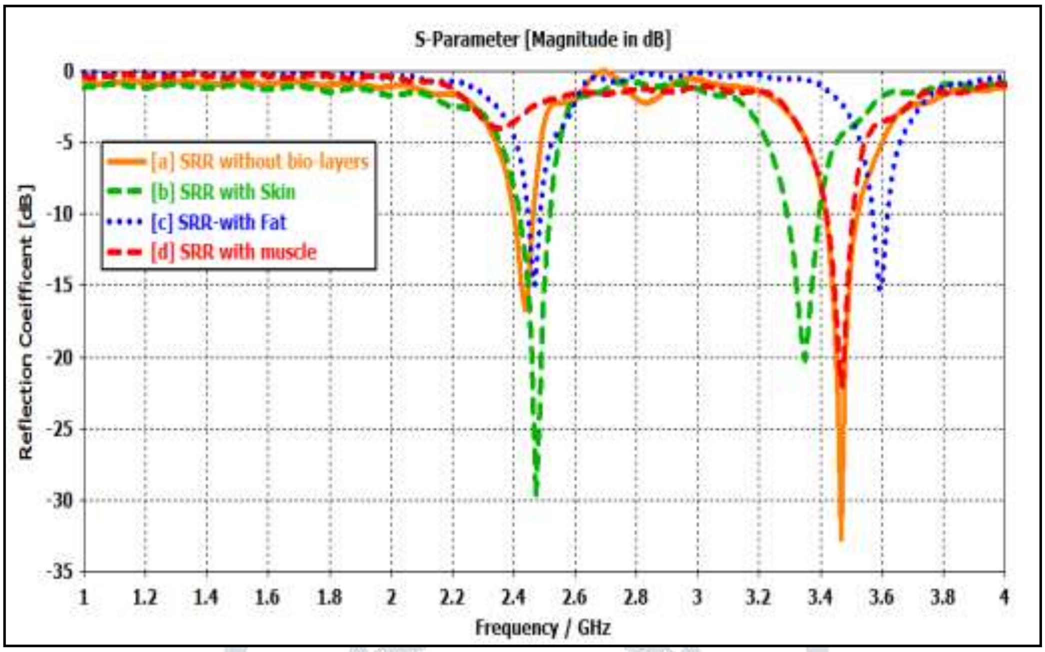

Fig.3.1 RC Vs frequency plot of HCDS PMA

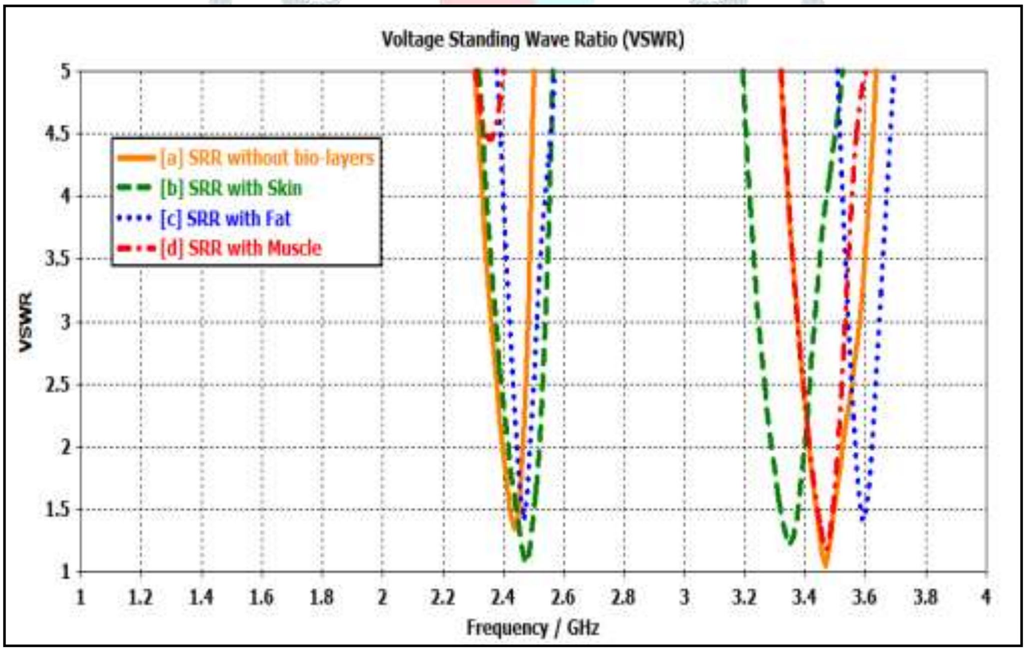

Fig.3.2 VSWR-Frequency plot for HCDS PMA

3.2 GAIN OF ANTENNA

The directive gain of the HCDS PMA is defined as the ratio of the radiated power by an AUT at a particular direction to isotropic antenna gain. The gain of PMA expressed in dBi. The mutual E-field and H-field interaction between SRR and HCDS structure gives a higher directive gain and bandwidth. The directive gain of the SRR loaded HCDS PMA is 2.6dBi at 2.45GHz and 5.1dBi at 3.5GHz, as shown in Fig.3.3 and Fig.3.4.

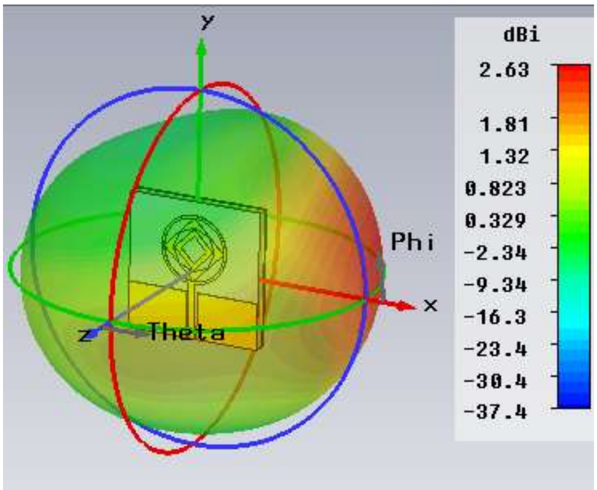

Fig.3.3 Directive gain of HCDS PMA at 2.45GHz

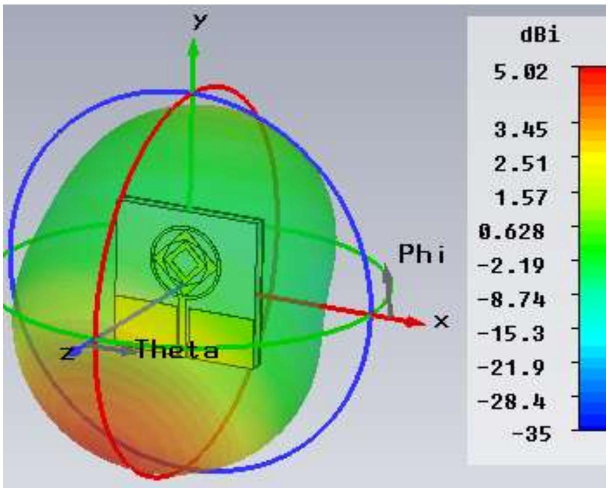

Fig.3.4 Directive gain of HCDS PMA at 3.5GHz

3.3 Radiation Pattern

The radiation pattern of HCDS PMA indicated the pointing vector field. The E-plane pattern is a function of angle of elevation with constant azimuth (Phi=90degree). E-plane pattern indicated the direction of electric field vector, which look like a drought shape as shown in Fig.3.5 and Fig.3.6.H-plane pattern as a function of Phi with constant theta (theta=0degree) [10]. The circular shape indicated the magnetic field pattern of HCDS PMA, as shown in Fig.3.7 and Fig.3.8.

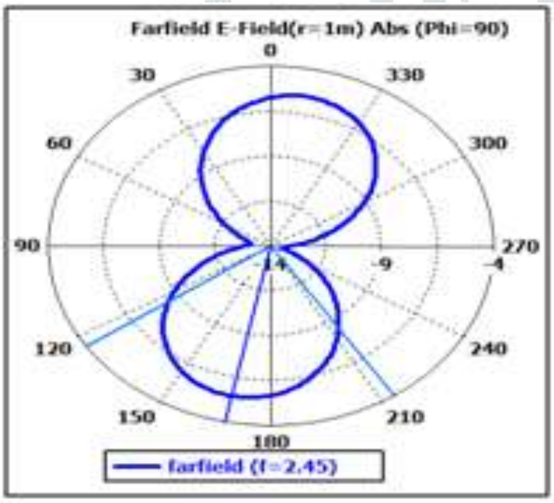

Fig.3.5 far field E-field pattern of HCDS PMA

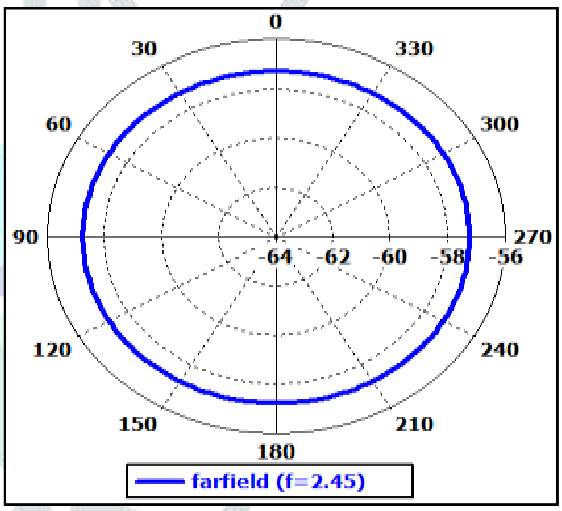

Fig.3.6 far field H-field pattern of HCDS PMA

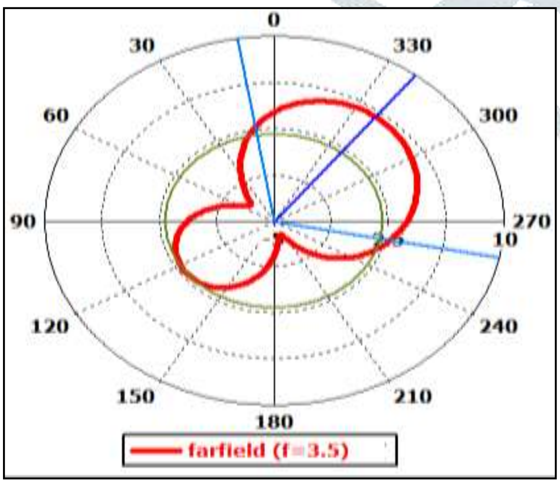

Fig.3.7 far field E-field pattern of HCDS PMA

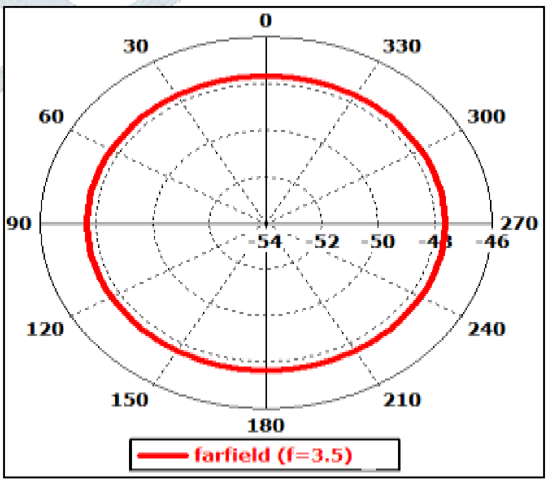

Fig.3.8 far field H-field pattern of HCDS PMA

Table. 3.1 Referred literature and HCDS PMA

Ref. literature	AUT [mm3]	Gain [dB]	BW [MHz]
[11] S. Fernandez, et.al	1524	-16	12
[12] T. Karacolak, et.al	1265	-25	142
[13] C.M. Lee, et.al	790	-27	120
HCDS PMA, f=2.45GHz	640	2.6	132
HCDS PMA, f=3.5GHz	640	5.1	148

4 CONCULSION

The HCDS PMA antenna is designed on the bio-compatible dielectric material (Teflon), also the CB-coplanar waveguide fed with an AMM loaded methods aid the miniaturization of the HCDS PMA. The overall volume of HCDS PMA is 20x20x1.6mm^3.The minimum value of RL is 34dB and corresponding SWR is 1.02. The simulated HCDS PMA parameters are further apt for ISM band and 5G-MSB band applications.

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