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Design of a Flexible PET Based Yagi Dipole Antenna

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***Abstract:** In the proposed paper, a flexible Yagi Dipole Antenna based on PET Substrate is designed for the RF system-on-package (RF SOP) applications. RF antenna as a smart sensor is designed on a Flexible substrate Polyethylene Terephtalate (PET). It is the more popular and universally accepted thermoplastic polymer belonging to the family of the polyester. It is generally employed in textiles, thermoforming packaging along with glass fibers. In the proposed design Coplanar Strip line (CPS) is used as a feeder and the RF antenna is a Yagi dipole Antenna with a single driven element i.e. director, and a single reflecting element i.e. reflector. It is a linearly polarized antenna which means it radiates in a single direction. The antenna is designed at a resonating frequency of 5 GHz with a return loss of -23 dB. Simulations of the flexible PET based Yagi Dipole Antenna is carried out by using CST Studio Suite software for Return loss, Radiation plot with varied curvatures. The results for designed flexible Yagi Dipole Antenna imprinted with a PET substrate for portable wireless electronics are analyzed.*

***Keywords:** Yagi Dipole Antenna, Coplanar Strip Line, Polyethylene Terephtalate, Return loss.*

I. INTRODUCTION

Over the past decade the manufacturing and design of flexible electronics has drawn major attention such as the development of wearable products, flexible displays and smart tags. Functionality integration is feasible in developing flexible microelectronics embedded with new technologies. The flexible Integrated Circuit technology has impacted heavily in the area of portable wireless applications [1][2]. Critical design aspects are integrating passive and active components on the same flexible substrate with reduced physical dimensions which enhances the performances of the microwave device with energy efficient packages.

Various techniques have been proposed by using divergent elements in the design of flexible materials as substrates [3]-[5]. Different polymer constituents like PEI, LCP, and PET are preferred as the substrate material in the design of RF electronic devices due to the striking characteristics of less relative dielectric constants and dissipation factors making them idle materials for making the laminates [5].

In the recent years, Polyethylene Terephtalate (PET) polymers have gained wide acceptability in the fabrication and design of Microsystems [6]-[9].

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For UHF and microwave applications, Polyethylene Terephtalate (PET) substrate is the best industrial-substrate candidate by varying the substrate density, coating, thickness, texture, etc. RF characteristics of a PET substrate should be evaluated before its realization in the design of UHF antennas.

In the proposed paper, flexible Yagi Dipole Antenna is designed with a low-cost substrate PET and the results are obtained with the CST Studio Suite software for Return loss, Radiation plot with varied curvatures. PET substrate generally finds its applications in textiles, thermoforming packaging along with glass fibers rather for the high frequency applications.

II. PROPOSED DESIGN

In the proposed design Coplanar strip line (CPS) is used as a feeder and the RF antenna is a Yagi dipole Antenna with a single driven element i.e. director, and a single reflecting element i.e. reflector. It is a linearly polarized antenna which means it radiates in a single direction.

The antenna is designed with a resonating frequency of 5 GHz of a return loss of -23 dB. Simulations of the flexible PET based Yagi Dipole Antenna are carried out by using CST Studio Suite software for Return loss, Radiation plot with varied curvatures.

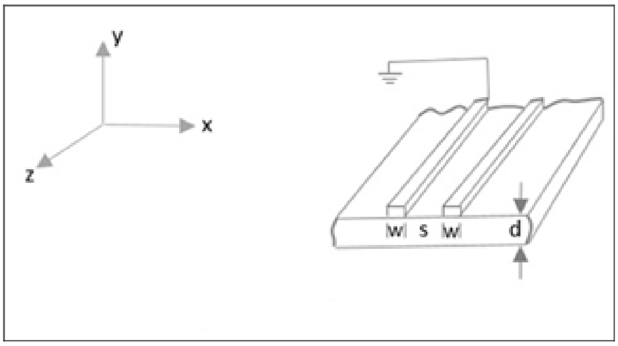


Fig.1.Coplanar Strip Line (CPS)

A coplanar strip line (CPS) comprises of two conducting strips on the identical substrate surface with one strip grounded and with no conducting layer. It provisions quasi-TEM mode providing low dispersive properties. The effects of shunt are completely eliminated by the CPS making them more reliable devices increasing the reproducibility and the production cost is reduced.

Flexible PET Based Yagi Dipole Antenna is designed by combining the both coplanar stripline and Yagi dipole antenna.

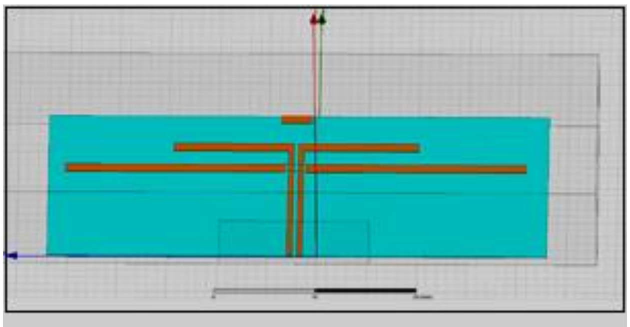


Fig.2.Coplanar Strip Line (CPS) fed Yagi Dipole antenna

Coplanar Strip Line (CPS) transmission feed to the dipole and the reflector has been split into two connected with bond wires. The designed antenna resonates at 5 GHz frequency with a return loss of -23db.
A radiation pattern is defined as the variation of the power radiated by an antenna as a function of the direction away from the antenna. The power variation is the function of the arrival angle observed in the antenna's far field.
Return Loss in the communications is defined as the loss of power due to reflected signal due to impedance mismatch or the discontinuity with the terminating load which is expressed as the ratio of incident power to the reflected power

$$\text{Return Loss (decibels)} = 10\log_{10}\frac{\mathit{Incident\ Power}}{\mathit{Reflected\ Power}}$$

The return loss is the performance measure of the antenna in terms of the impedance matching. Return loss is associated with Voltage standing wave ratio (VSWR) and reflection coefficient

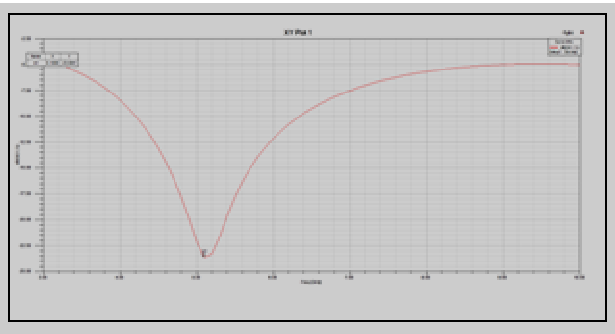


Fig.3. Return loss

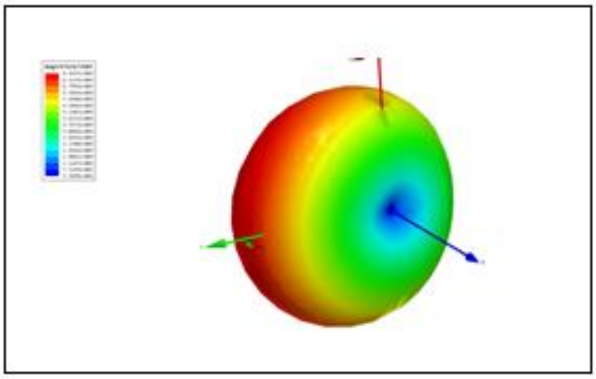


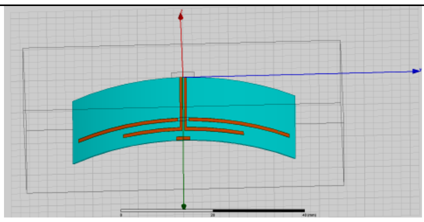
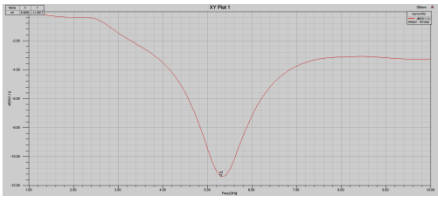
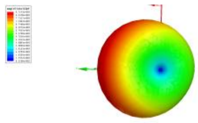
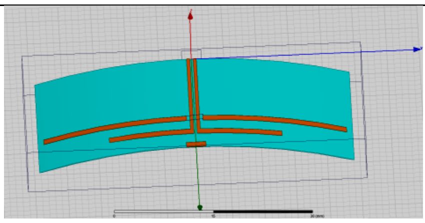
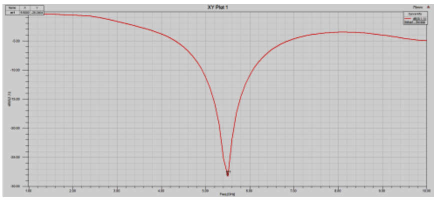
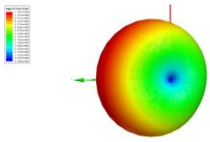
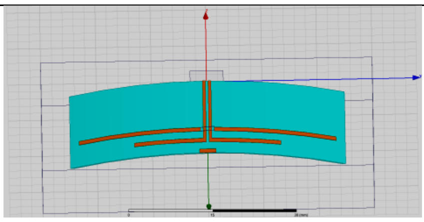
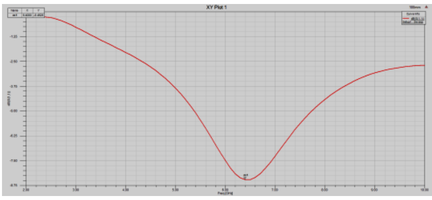
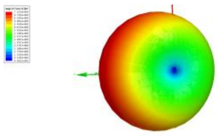
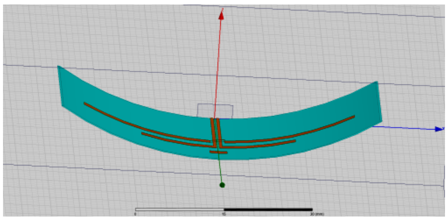
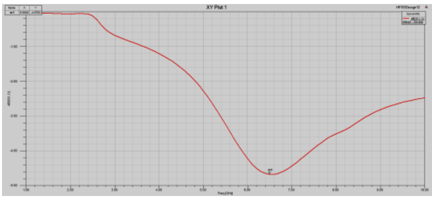
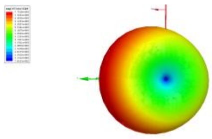
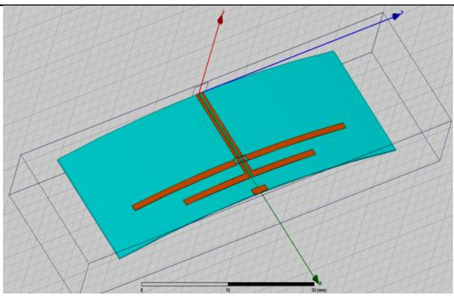
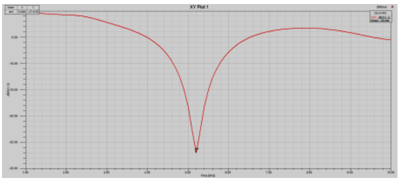
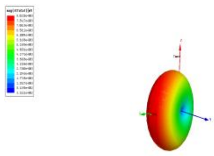
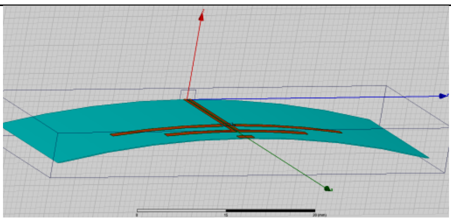
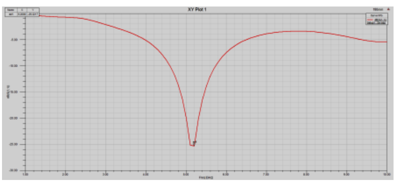
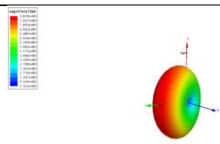
Fig.4.Polar Plot

III. SIMULATION AND MODELLING

The integrated design environment, CST STUDIO SUITE [10] is the effective simulation tool for the design of electromagnetic systems designs which are most accurate and reliable. Computer Simulation Technology Microwave Studio (CST MWS) [11] is the important edge means for the accelerated and precise 3D simulation of Microwave frequency designs. It allows the quick and precise design of filters, antennas, couplers, planar and multi-layer structures.

IV. RESULTS AND DISCUSSIONS

By changing the curvature of the Coplanar Strip Line (CPS) transmission feed to the dipole antenna, the results are simulated for the Return loss and Polar plots.
The figure 5- 22 represents the return losses and polar plots of the antenna with various curvatures ranging from the 50 mm -300 mm. The Figure 23 represents the accumulated return losses of the same antenna with various curvatures together.
The figure 24 represents the return losses of the same antenna with various inverted curvatures together. Figures 25-32 depicts the polar plots of the inverted curvatures of the same designed antenna.
Figure 33 and 34 shows the electric field and magnetic field of the antenna at 90° phase.
Simulations of the flexible PET based Yagi Dipole Antenna are carried out by using CST Studio Suite software. The results for designed flexible antenna provided better performance in terms of return loss characteristics, bandwidth with acceptable radiation patterns.

 **Fig.5. Curvature 1**	 **Fig.6. Return loss -11 dB**	 **Fig.7. Polar plot**
 **Fig.8. Curvature 2**	 **Fig.9. Return loss -28 dB**	 **Fig.10. Polar plot**
 **Fig.11. Curvature 3**	 **Fig.12. Return loss -8 dB**	 **Fig.13. Polar plot**
 **Fig.14. Curvature 4**	 **Fig.15. Return loss -4 dB**	 **Fig.16. Polar plot**
 **Fig.17. Curvature 5**	 **Fig.18. Return loss -27 dB**	 **Fig.19. Polar plot**
 **Fig.20. Curvature 6**	 **Fig.21. Return loss -25 dB**	 **Fig.22. Polar plot**

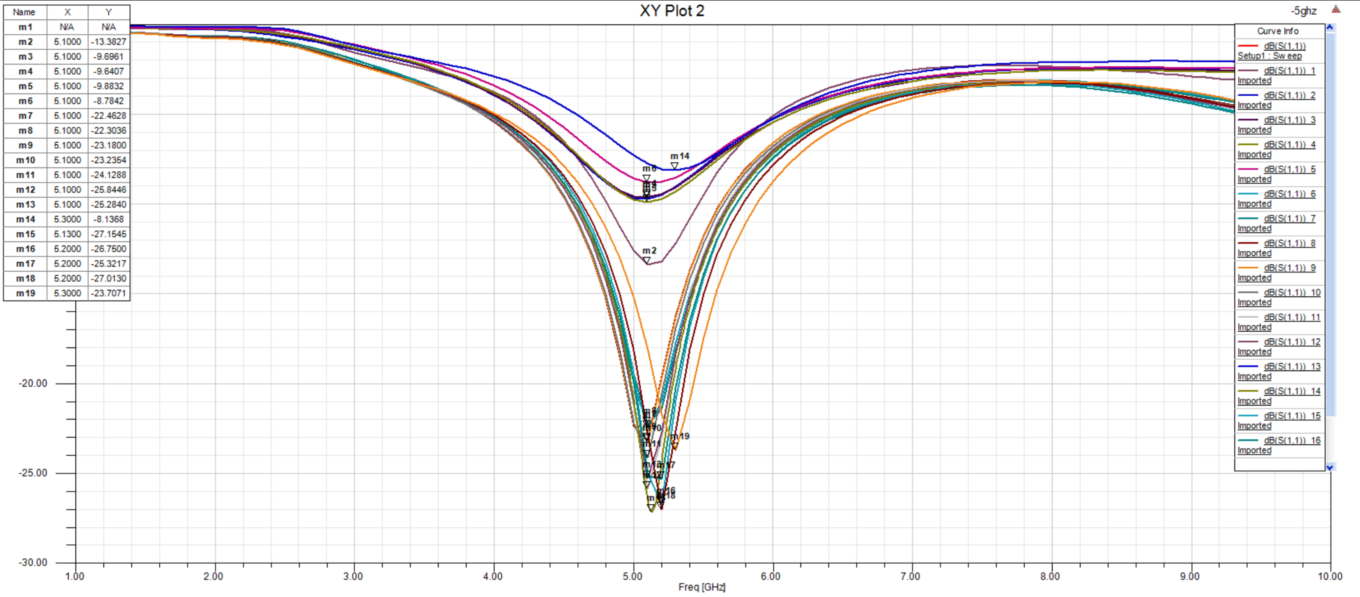


Fig.23: Accumulated results of Return loss

The Figure 23 represents the return losses of the same antenna with various curvatures together

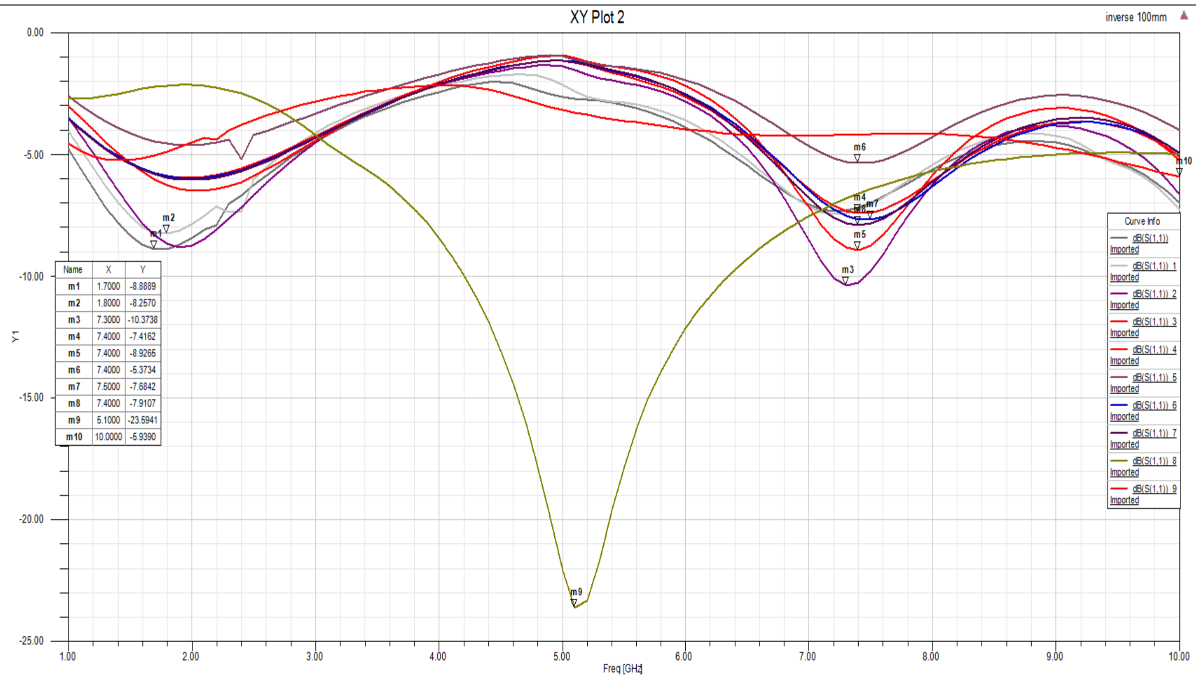


Fig.24. Accumulated Return Loss Results of the Inverted Curvatures

The Figure 24 represents the return losses of the same antenna with various inverted curvatures together

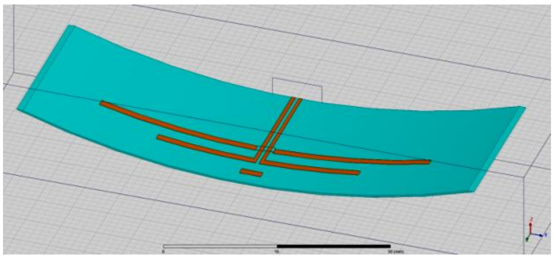


Fig.25. Inverse Curvature 1

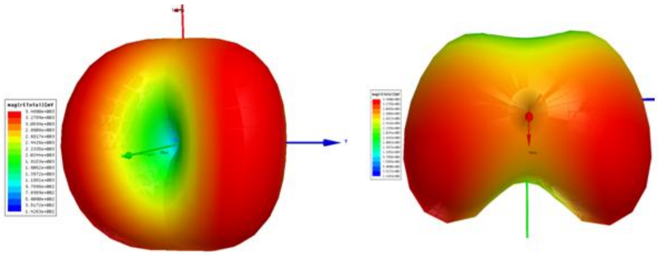


Fig.26. Polar plot

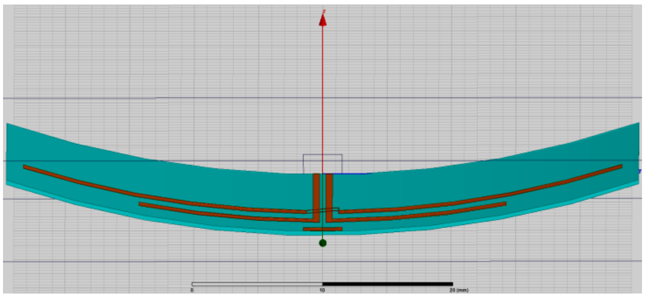


Fig.27. Inverse Curvature 2

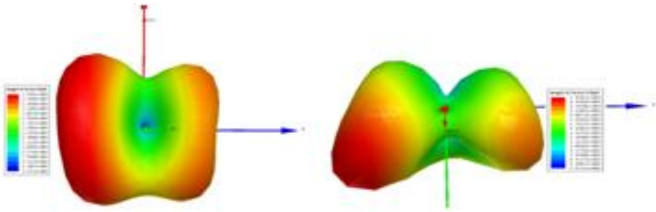


Fig.28. Polar plot

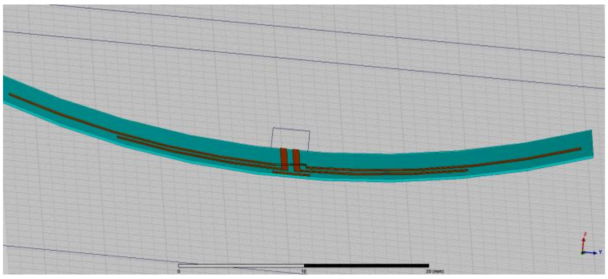


Fig.29. Inverse Curvature 3

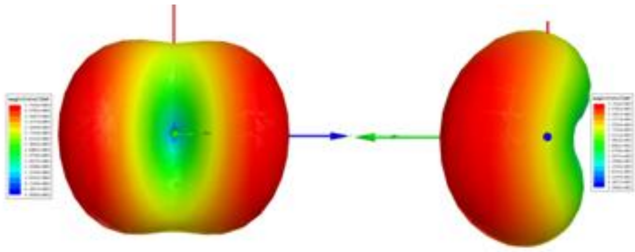


Fig.30. Polar plot

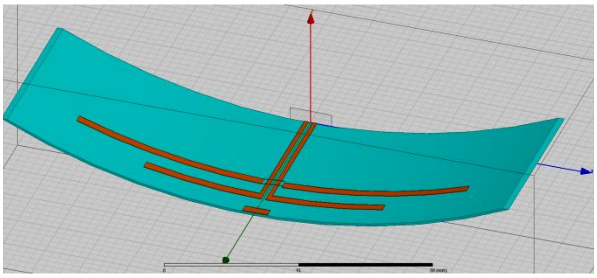


Fig.31. Inverse Curvature 3

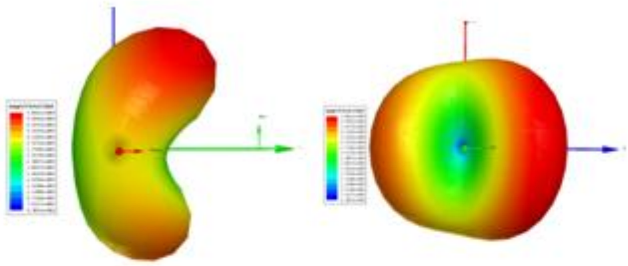


Fig.32. Polar plot

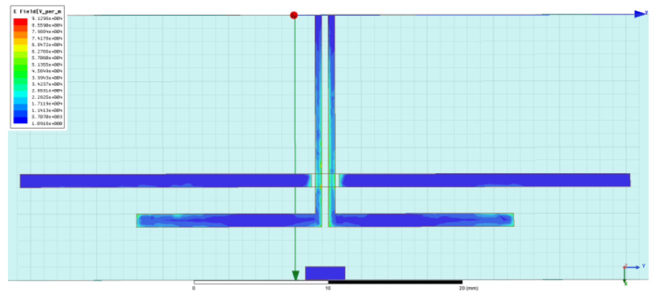


Fig.33. Electric field- Magnitude

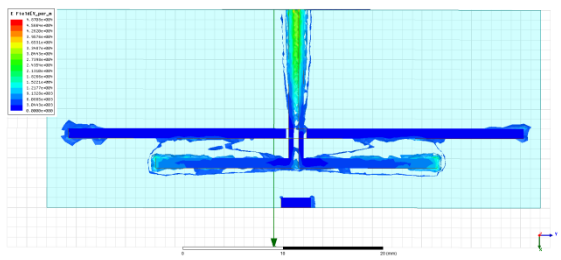


Fig.34. Magnetic field- Magnitude

IV. CONCLUSION

In the proposed design Coplanar strip line (CPS) is used as a feeder and the RF antenna is a Yagi dipole Antenna with a single driven element i.e. director, and a single reflecting element i.e. reflector. Flexible PET Based Yagi Dipole Antenna is designed using the low-cost and flexible material Polyethylene Terephtalate (PET). The Yagi Dipole Antennais designed at a resonating frequency of 5 GHz with a return loss of -23 dB using the simulation tool and results are obtained for the Return loss, Radiation plot with varied curvatures. Simulations of the flexible PET based Yagi Dipole Antenna are carried out by using CST Studio Suite software. The results for designed flexible antenna provided better performance in terms of return loss characteristics, bandwidth with acceptable radiation patterns

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