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A Literature Survey on Flexible Wearable Trans-Receiver Tuning For Wireless Communication

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***Abstract*— The current generation of wireless communication is based on Wi-Fi and Wi-Max devices. Most of the communication devices are worked on non flexible tuning element. In the survey paper discuss on the flexible wearable antenna. Flexible antenna is the next generation technology. In this reseach work discuss the different flexible substrate and based antenna. Flexible substrate play an important role for designing of next generation patch antenna. Also shows the different literature survey on flexible antenna presented in the last decade by different researcher The major substrate are used by kapton substrate, polyimide Substrate, paper substrate, kapton polyimide substrate, inexpensive flexible substrates, Flexible substrate and blend substrate.In the survey paper also shows the comparative analysis of different research work on the basis of shape and method adopted for designing.**

***Keywords*— Dipole Antenna, CST, VSWR, Gain, Wi-Fi, Printed Dipole Antenna, and Wi-Max**

I. INTRODUCTION

Flexible and wearable antennas have attracted considerable attention recently due to their potential advantages of low-cost, lightweight, reduced fabrication complexity, convenient integration, and conformability. The utilization of the inexpensive flexible substrates (i.e., polyimide, research works, plastics, and polyethylene) is used instead of using rigid and brittle one.The microstrip patch antennas have got a good attention due to its planar configuration, lower profile, and effortlessness integration with connected electronics. Since the inception of microstrip antenna tremendous research effort has been made to meet the impedance and radiation pattern requirement of the modern compact wireless communication devices. However, due to their lower profile and compact size benefit, microstrip antennas have to face the narrow impedance bandwidth challenge.A **s**ubstrate (also called a wafer) is a solid (usually planar) substance onto which a layer of another substance is applied, and to which that second substance adheres. In solid-state electronics, this term refers to a thin slice of material such as silicon, silicon dioxide, aluminum oxide, sapphire, germanium, gallium arsenide (GaAs), an alloy of silicon and germanium, or indium phosphide(InP). These serve as the foundation upon which electronic devicessuch as transistors, diodes, and especially integrated circuits (ICs) are deposited. Flexible substrate can be defined as a technology for assembling electronic circuits by mounting electronic deviceson flexible plastic substrates, such as polyimide, PEEK or transparent conductive polyester film. Additionally, flex circuits can be screen printed silver circuits on polyester. Flexible substrates may be manufactured using identical components used for rigid printed circuit boards, allowing the board to conform to a desired shape, or to flex during its use.The Many studies have significantly contributed to improve the performance of printed antennas using metals like silver, copper, or gold because of their high electrical conductivity. However, noticeably less research has been dedicated to the development of printed antennas using conductive polymers.

1.2 Flexible Antenna

Flexible antennas operating in wireless local area network (WLAN) can provide a route to creating high speed wireless data transmission systems that can be combined with other flexible devices to transmit and receive signals in a myriad of applications. Antenna designs utilizing novel materials and techniques have been demonstrated in flexible forms. However, many of the antennas were incompatible with existing flexible electronic devices, or limited by rigid substrates that were too thick to be integrated in the body. Moreover, most of the reports use tissue mimicking gels as their design parameters, but such approach does not prove that the antennas may be used in practical applications.

INKJET printing technology is investigated and wide utilized as another fabrication methodology to the conventional subtractive fabrication ways, like milling and etching. Inkjet printing could be a kind of computer printing that recreates a digital image by propellant droplets of ink onto paper, plastic, or different substrates. Inkjet printers are the most commonly used type of printer, and range from small inexpensive consumer models to expensive professional machines. The importance of "green", scalable and cost-efficient technology is ever increasing for numerous applications like the Internet of Things (IoT), the radio frequency identification tags (RFIDs), and the wireless sensor networks (WSNs). The inkjet printing technology does not produce any byproducts because it only deposits the controlled amount of functionality inks such as silver nano particles on desired position. damaged.

II. LITERATURE SURVEY

Amal Afyf et.al. [2020], In this research work author represent a flexible and body centric trans-receiver device for S band. The new structure improves on previous passive microwave imaging systems in that it is highly flexible, cost-effective to fabricate, and light-weight. Simulations were carried out with CST, exploiting a layered (inhomogeneous) model with different dielectric constants and loss tangents to capture the effect of surrounding tissues[1].

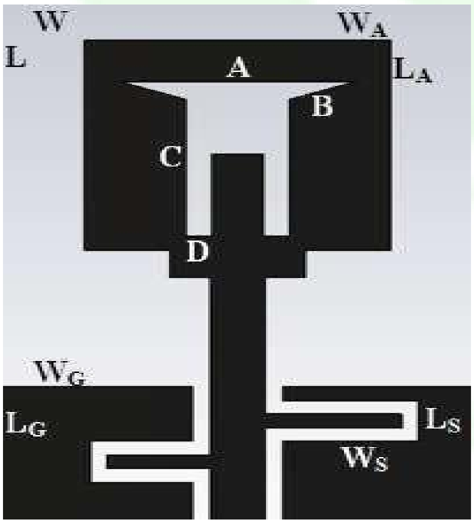


Fig. 1.flexible CPW antenna

Wang, Chao, et.al.[2019], This work present a low-cost and highly flexible patch antenna for IoT applications in the 2.4 GHz ISM band was fabricated using a commercial of the shelf (COTS) flexible silicone sponge rubber substrate backed by a flexible copper wire mesh in order to demonstrate feasibility of the materials as a substrate for flexible and conformal RF devices. The presented antenna can be significantly deformed mechanically without deterioration in RF performances when conformed to a surface with high curvature radius, except for the maximum gain which steadily decreases from the flat case to the case of R = 35 mm,for a total reduction in maximum gain of 1.96 dBi due to the decrease of the antenna equivalent aperture. The antenna can be flexed repeatedly without any permanent damage, which enables application such as flexible conformal patch array and mechanical beam steering for example[2].

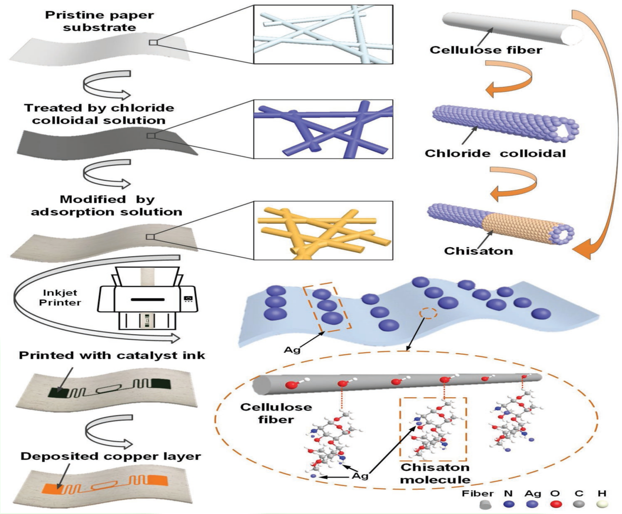


Fig. 2. Fabricating Process Flexible RFID on paper substrates via Inkjet Printing

Li et.al. *[2018],* A patch antenna having the inkjet-printing of bandwidth-enhanced is presented with detailed simulation and measured results. The designs which are used are multi-layer and fractal designs for getting a compact size of the antenna. The measured impedance bandwidth for |S11|<−10 dB covers 4.79–5.04 The antennas which are inkjet printed show steadiness and tolerance under different bending radii of curvature. A 2-bit, 4-element PAA is been made and proved to work well through the beam steering experiments. These fabrication method of the antenna used in this paper shows the potential applications in on-package and on-chip printed antennas [3].

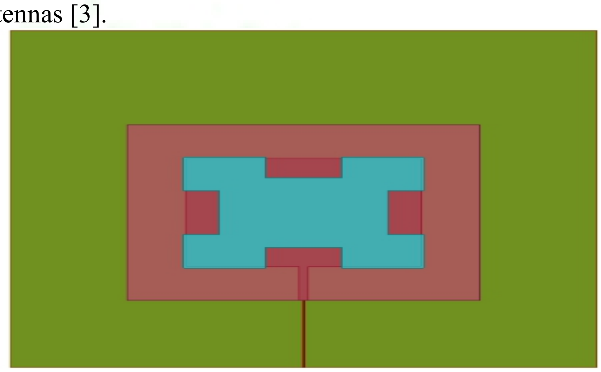


Fig. 3. Top view of Flexible Inkjet antenna

Kumari et.al. [*2016],* In this the study of multi band Bow Tie antenna with circular arm and fractal geometry is given. The multi band operation is achieved by Apollonian Gasket of Fractals which is the combination of mutually tangent circles. 3 iterations have been designed in this antenna and the best result is obtained in 2nd iteration. The two circular slots have also been cut and the UWB band is gained. The resonating frequencies came out were 4 having a very low reflection co efficient. The antenna is fabricated using etching process and tested using VNA. The given antenna shows a good omni directional radiation pattern. The efficiency gained every time is more than 40%. It is simulated by in ZELAND IE3D 15.3 software and validates the purpose of this antenna to be used in satellite, cellular mobile and radar application[4].

Shao et.al [*2015*],An elastic RFID tag antenna is been made here which is a textile-based broadband, fabricated and tested. The antenna which was designed here gets a bandwidth of 263MHz in free space. It also upholds its tuned behavior when placed on dielectrics with unstable permittivity. Many versions were also made and tested. The outcome was that the designed tags give better performances when judged against an existing commercial tag. The work done by the tag antenna then doesn't decrease its efficiency under mechanical deformation up to 10%, which makes it a good candidate for elastic and hostile environments[5].

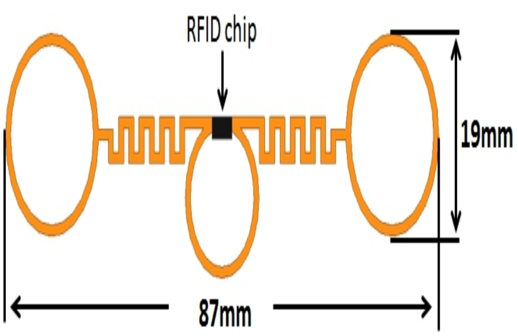


Fig.4 Design of the Flexible RFID tag antenna

Naidu et.al [*2015*],The process of making a compressed ACS-fed antenna having multiple bands. The testing of the sample is been done here.The resonances are independently tunable. The measured impedance bandwidths are about 200 MHz from 2.40–2.60 GHz, and 2800 MHz from 3.2–6.0GHz. The good return loss characteristics, compact size with simple geometry, wide impedance bandwidth with omni directional radiation patterns along with acceptable peak gains make the proposed antenna a suitable candidate for 2.4 GHz Bluetooth/ Wi-Bree/ Zigbee, 2.4/5.2/5.8 GHz WLAN, 3.5/5.5GHz Wi-MAX, 5.9GHz WAVE and 4.9 GHz US public safety system applications. The technique is validated by designing another similar antenna operation in 1.8/1.9 PCS, 3.5/5.5GHz Wi-MAX, 5.2/5.8GHz WLAN bands [6].

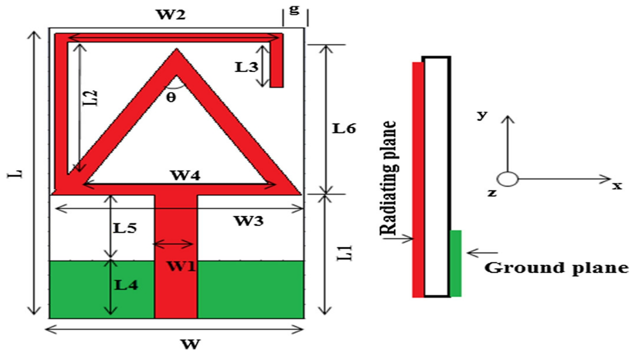
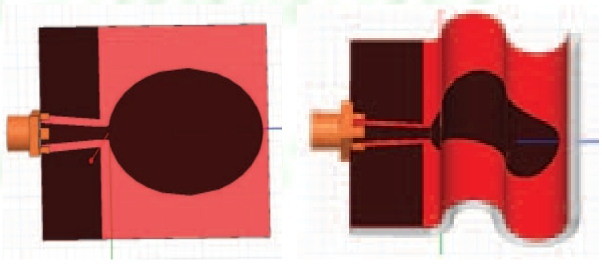


Fig. 5 Geometry of the Flexible dual-band microstrip antenna

Hamouda et.al [*2015*] ,In this study, an organic antenna using multi wall CNTs doped PANI is proposed. Kapton is been selected and used as it offers wanted mechanical properties (lightweight, flexible and conformal) which allow the development of mechanically flexible planar antennas having the complex geometries. Crumpled antennas are been made with kapton due to its flexibility and of the doped conductive polymer made it possible to make a good antenna. The measured resonant frequency peaks are situated around 1.9 and 5.7 GHz offering a dual-band operation. These peaks present a −10 dB bandwidth of 51% and 60%, respectively, which permits to cover the frequency bands of interest (PCS, WLAN, and wireless network). The derivation derived for the gain that has been found to be quite similar in simulation and measurement studies. The realized gain at 5.8 GHz is about 2.48 dBi. The prospect of incorporating them in future flexible electronic devices which are operating in multiple frequency bands and in body-worn electronics without impairing mechanical and electrical properties[7].



(a) **(b)**

Fig. 6. HSSF layout views of antennas designed on kapton substrate with (a) uncrumpled and (b) crumpled structures.

Quarfoth et.al [*2015*] The metal surfaces with patterns on it is used to design a flexible antenna. Usage of metal is done because it is useful in stretching or contracting during bending without plastically deforming or breaking. The metal sheets are joined to each face of a silicone substrate and that's how an antenna is been designed.The antenna can be bent in any direction and maintains its shape in either flat or bent positions and the frequency shift is also very low or minimal on bending. The antenna gain was slightly lower than an ideal patch due to losses in the silicone substrate and the patterned metal. The metal sheets which were used in here were also embedded in an RTV silicone sealant [8].

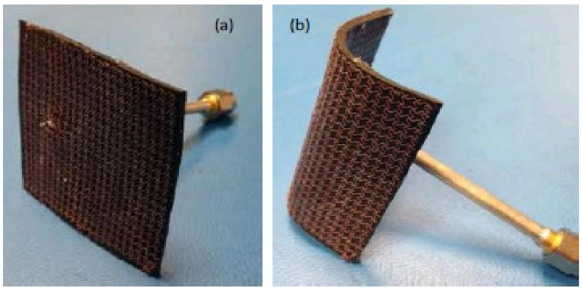


Fig. 7. Fabricated flexible antenna. (a) shows the flat antenna, and (b) shows the same antenna while bent.

Jung et.al. [*2015]* The flexible antenna with a Parylene C coating with good electrical performance in WLAN frequency has been presented and the coating and bending gives a negligible effect in its performance. The tuning of the WLAN antenna for implantable applications is been displayed. When different types of tissues and animals have been taken for the experimentation, the electrical parameters vary; this technique presents a simple approach in fabricating an implantable antenna. Study of the effect and impact from radiation and specific absorption rate (SAR) on the body remains one of the future tasks. If this design gets its success then an antenna originally designed for operating in air can give some instructive hints for designing implantable antennas that can transform from various types of existing antennas that were originally designed to operate in air [9].

Fig. 8. Geometry and dimensions of designed antenna

Kim *et.al.*[*2016]*The inkjet printing process of silver nano particles on thick substrates, such as a PMMA and RT/Duroid 5880, for microwave applications as well as the fabrication process of fully inkjet-printed low-cost vias and SIW components are made. The inkjet-printed silver nano particle inks on PMMA feature good conductivity values (4.5x106 ~8.0x106 S/m) to implement practical microwave topologies. The totally inkjet-printed vias on the PMMA substrate were enforced by introducing a unique stepped via whole configuration with an exponentially tapered radial profile[10].

(a) (b)

Fig. 9 (a) Perspective view of the fabricated antenna. (b) Rear view of the fabricated antenna

III. Flexible Substrate

For the deigning of flexible Tunable patch required flexible substrate. In this section discuss the various flexible substrate theses are used.

A. Kapton Substrate- It's used in the design makes the antenna suitable for being implemented or pasted on clothes.

B. Polyimide Substrate- It's a flexible substrate with a thickness of HS and dielectric constant of 3.4. In order to maintain the flexibility of the antenna.

C. Paper Substrate- In this flexible substrate. There are no proper anchor point that catalytic ion can bond with on the substrate. Therefore, the adhesion of copper layer deposited on the paper substrate is not enough for the metal antenna of RFID tags.

D. Kapton Polyimide Substrate- The substrate selected is kapton because it offers desirable mechanical properties (flexible, conformal, and lightweight) allowing the development of mechanically flexible planar antennas with potentially complex geometries.

E. Inexpensive Flexible Substrates- polyimide, papers, plastics, and polyethylene are use as inexpensive flexible substrate, instead of using rigid and brittle.

F. Flexible substrate- is soldered at the front center to form a circular shape. The inner and outer conductors of the coaxial cable are connected to the left and right sides of the feeding gap (g1), respectively.

G. Blend substrate- blend substrate which can be three-dimensional for irregular plastic materials to be embedded inside the device as internal antennas.

IV. Conclusion

In this survey paper discuss the flexible substrate based Tunable antenna. Flexible substrate play an important role for designing of next generation patch antenna. Also shows the different literature survey on flexible antenna presented in the last decade by different researcher The major substrate are used by kapton substrate, polyimide Substrate, paper substrate, kapton polyimide substrate, inexpensive flexible substrates, Flexible substrate and blend substrate.In the survey paper also shows the comparative analysis of different research work on the basis of shape and method adopted for designing.

Table - 1Comparative Analysis of Different Flexible Antenna

Sr.No.	Title	Author Name	Year	Method	Shape
1	Flexible Wearable Antenna for Body Centric Wireless Communication in S-Band	Amal et.al.	[2020]	CST-MWS	Π- shaped slot
2	Flexible RFID Tag Metal Antenna on Paper-Based Substrate by Inkjet Printing Technology	Wang Chao et.al.	[2019]	RFID	U-shape
3	Inkjet printing of wide band stacked microstrip patch array antenna on ultra thin flexible substrates	Li et.al.	[2018]	"Subtractive" manufacturing method	U-shape
4	Broadband textile-based passive UHF RFID tag antenna for elastic material	Shao et.al	[2015]	UHF RFID	rectangular shape,
5	Design, simulation of a compact triangular shaped dual-band microstrip antenna for 2.4 GHz Bluetooth/WLAN and UWB applications	Naidu et.al	[2015]	CPW	triangular shaped
6	Dual-band elliptical planar conductive polymer antenna printed on a flexible substrate	Hamouda et.al	[2015]	stencil printing method	crumpling shape
7	Flexible patch antennas using patterned metal sheets on silicone	Quarfoth et.al	[2015]	Inkjet printing methods	general shape
8	A compact parylene-coated WLAN flexible antenna for implantable electronics	Jung et.al.	[2016]	CPW	U-shape

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