Flexible Wide Band Ultra-Thin Microstrip Patch Antenna for WLAN Application

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Abstract— In this work proposed design a multi-layer flexible ulta thin patch antenna for WLAN and Wi-Fi Wi-Max antenna. This presented work shows the design of multi-layer monopole patch antenna with rectangular slots. The proposed design shows good result as compared to other previous method's results on the basis of basic antenna parameters such as VSWR, gain, Return Loss and bandwidth. The proposed antenna shows a wide band and cover Wi-Fi [13] and Wi-Max [13] ranges whose frequencies is between 2 to 6 GHz. The range of proposed design cover the wireless fidelity and Wi-Max range. The overall gain of proposed antenna is above 4db. Also shows the good result in terms of return loss that is (S-11) -58 dB as well as VSWR that is 1.02 and important parameter is percentage bandwidth is 80.00%.

Key words: Return Loss, Wireless Local Area Network (WLAN), Wi-Fi, Wi-Max, Flexible Antenna

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. Flexible substrate can be defined as a technology for assembling electronic circuits by mounting electronic devices on 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.

A. 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 functionalized inks such as silver nano particles on desired position.

II. Literature Survey

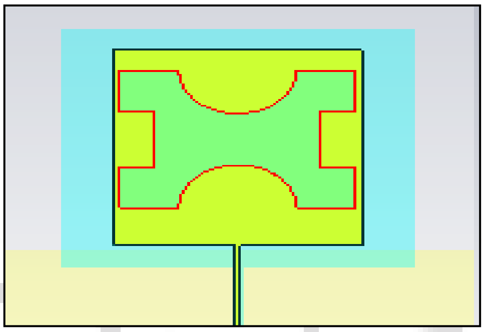
In 2018 proposed the inkjet-printing of bandwidth-enhanced is presented with detailed simulation and measured results. The designs which are used are Multilayer and fractal designs for getting a compact size of the antenna. The measured impedance bandwidth for $|S11| < -10$ dB covers 4.79–5.04 GHz.[01]. In 2016 this the study of multiband Bow Tie antenna with circular arm and fractal geometry is given. The multiband 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 four 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 [09] 2015 An elastic RFID tag antennaisbeen 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. Naidu et.al [10] 2015 The process of making a compressed ACS-fed antenna having multiple bands. The testing of the sample is been done here. The design mentioned here has three different simple radiating elements which motivate the resonant frequencies needed. 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. Hamouda et.al [11] 2015 In this study, an organic antenna using multiwall 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. Quarfoth et.al [12] 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, and can also be used with other flexible substrates as well.

III. PROPOSED DESIGN

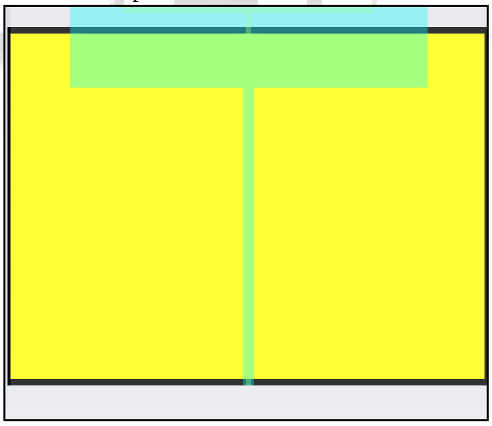
In this presented work shows the flexible antennas. These antennas have attracted considerable attention recently due to their potential advantage of low-cost, lightweight, reduced fabrication complexity, convenient integration, and conformability. The utilization of the inexpensive flexible substrates (i.e., polyimide, papers, plastics, and polyethylene), instead of using rigid and brittle substrates, makes flexible electronics an appealing alternative for the current electronics technology. In this antenna apply defected ground structure (DGS) technique to enhance bandwidth (B.W.) and gain (G) of the antenna. Flexible and wearable antennas patch antenna has become popular day by day the reason behind this is ease of flexibility and fabrications in cloths. Flexible patch antenna is designed for Giga hertz frequency range 1 to 6 GHz.

A. Proposed Wide Multi-Layer Microstrip Patch Antenna

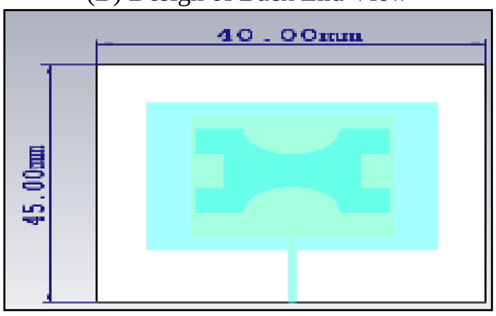
In the research work present a multilayer microstrip monopole fractal patch antenna for integration into flexible and conformal devices, it is good step for flexible technology. During this evolution two vital standards are Wi-MAX and Wireless local area network antennas are standard for its well-known engaging options, like a small size, easy to fabricate and easy to use. The demand of flexible antenna is increasing rapidly due to its good properties such an easy to fabricate, easy to fit any communication device and also use in different places where require flexible technology structure. For the flexible technology in antenna use different type of substrates such as Graphene, copper indium gallium.The next generation of technology is based on flexible electronics, for the growth of this technology, proposed flexible antenna shows a vital role.



(A) Design of Front View of Multilayer Microstrip Monopole Fractal Patch Antenna



(B) Design of Back End View



(C) Shows the Dimension of Substrate

Fig. 1: Multilayer Microstrip Monopole Fractal Patch Antenna Front Patch Side, Back Ground Side & Substrate

In the below figures shows the design specification of the proposed design. The proposed design contain five different layer or parts. There are ground, substrate, patch1, and patch 2, fractal design. In the below figure 1 (a) and (b) shows the patch and ground of the proposed design , (c) shows the substrate, d shows patch 1 and e shows patch 2 of proposed design. .The main motive of this research work is to design a flexible antenna for this use a thick flexible Rogers RO4003C substrate (ε_r= 3.38 and tan δ = 0.0027).The length(L), width (W) and height (H) of the proposed design is shown in table 1 that is $(40 \times 45 \times 0.49)\mathrm{m.m}^3$design. Now discuss the last but very important of flexible antenna that is patch of proposed antenna. The geometry of proposed design is shown in the figure 1 (a). The length (L) and width (W) are same as the substrate but height (H) is changed. Also apply tiny microstrip feed of 1mm that is connect by waveguide port or coaxial port, also apply parametric study in the microstrip line. In the waveguide port or coaxial port using 50 Ω impedance value

Antenna Parts	Antenna dimension	Dimension Length(L) × Width (W) × height(h)mm3
Substrate (s)	Substrate (s) RT durioid	$40 \times 45 \times 0.125$
Ground (G)	Ground (G1) Copper	$40 \times 13 \times 0.0635$
Patch (P)	P1[Rectangular pole Copper]	$21 \times 23 \times 0.0635$
	P2[Rectangular pole SU8]	$30 \times 28 \times 0.12$
Microstrip feed line (f_l)	P1feed line (f_L) P2 feed line (f_L)	$(0.6{:}\,0.2) \times 10 \times 0.0635$ $1 \times 10 \times 0.12$

Table 1: Dimension of Antenna Design

In the table I shows the all parameter of antenna design specification of proposed antenna. In this antenna dimension are length (L), width (W) and height is 40mm, 45mm and 0.497 mm. The dimension of ground is 48 mm and 13 mm is used in this proposed antenna.

In the upper side place modified Minkowski fractal geometry. The dimension of proposed fractal geometry,. The parameter values geometry discussed in the table II.

Parameter	W 1	L1	R	L2	W2
Value (m.m.)	20	16	5	6.5	3.0

Table 2: Fractal Patch Dimension

IV. SIMULATION & RESULT

The multi-layer flexible patch based microstrip patch antennas have gaining importance in the applications of Wireless Local Area networks (WLAN), Wireless Fidelity. The simulated results such as Return Loss (S_{11}), VSWR and Radiation Pattern, Bandwidth and Mesh field. The details of the result antenna designs and simulated results are presented in this chapter. New micro strip antennas have enhanced gain and bandwidth is presented in this thesis.

A. Return Loss

Return loss (S-11) is an important parameter for performance measurement of antenna that is measure is DB. It is the Return loss measure in Db. It is defined as the ratio of output verse input power received by transmitter. The return loss is expressed by –

$$\mathrm{S11(dB)} = 10\log\frac{P_r}{P_i} \qquad 5.1$$

– P_r – Received Power of the antenna
– P_i – Input Power of the antenna

B. Gain

Gain is representing as a ratio of radiation intensity in particular direction to total input power transmitted by antenna.

$$\text{Gain (G)} = 4\pi\frac{\text{radiation intensity}}{\text{P total}} \qquad 5.2$$

C. Results of Proposed Design

For the improvement of above result in the design two apply half circular cut of the upper patch in the design that is the final robust proposed design. The dimension and other parameters are already discussed in the previous chapter final design. The result of proposed design better in such result parameters, they are bandwidth (B.W.), gain (G), return loss (S-11) and radiation pattern of the antenna.

Return Loss (S -11)

It is the power loss in the signal that is reflected due to discontinuity in the transmission line.

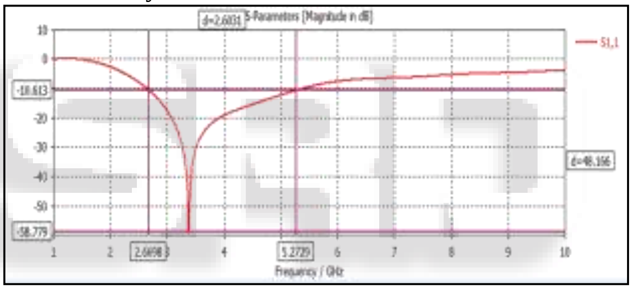


Fig. 2: Return Loss (S-11) of Proposed Antenna 3 (Single Wide Band)

S. No.	Parameter	Base Paper 2017 [01]	Proposed
1	Sub. Height (m.m.)	0.245	0.125
2	Relative B.W.	5.10%	82.35%
3	Return Loss	-25 db	-58 db
4	Sub. Constant	3.4	2.2
5	Covered Range	4.8 to 5.1 GHz	2 to 6 GHz

Table 3: Comparison with Base Pape

Ref. Pap.	Sub. Height (m.m.)	Relative B.W.	Flexibility
[03]	0.135	3.80%	Yes
[18]	5	5.90%	No
[19]	3	6.30%	No
[20]	…….	2.10%	Yes
[01]	0.245	5.10%	Yes
Proposed	0.125	80%	Yes

Table 4: Comparison with different previous methods

The proposed design shows better result as compare to other method. In the above table IV in terms of Sub. Height (m.m.),bandwidth (B.W.), size of antenna and number of bands. In the above table 3 and 4 compare the proposed work with different previous antenna. In the next chapter discuss the conclusion and future work of proposed method.

V. Conclusion

This presented work shows the design of multi-layer monopole patch antenna with rectangular slots. The proposed design shows good result as compared to other previous method's results on the basis of basic antenna parameters such as VSWR, gain, Return Loss and bandwidth. The proposed antenna shows a wide band and cover Wi-Fi [13] and Wi-Max [13] ranges whose frequencies is between 2 to 6 GHz. The range of proposed design cover the wireless fidelity and Wi-Max range. The overall gain of proposed antenna is above 4db. Also shows the good result in terms of return loss that is (S-11) -58 dB as well as VSWR that is 1.02 and important parameter is percentage bandwidth is 80.00%.

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