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A Flexible Wearable Trans-Receiver Tuning Element for Wireless Communication

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***Abstract*—The current generation of wireless communication is based on Wi-Fi and Wi-Max devices with dual-polarized antenna is demonstrated. In this research work represent the mathematical simulation of improved printed dipole antenna for WLAN application. In proposed antenna design, using a CST software simulation is employed to analyze the entire structure. The properties of antenna such as bandwidth, radiation pattern and half power beam width have been investigated. . In this proposed work design a half wave dipole antenna with change of the material properties and change the length of dipole. The simulated result of the proposed work shows better gain, bandwidth and number of the bands of the antenna. Also improve the VSWR and other result of proposed work.**

Keywords*—*Dipole antenna, CST, VSWR, Gain, Wifi, Printed Dipole antenna, Half wave dipole and Wi-Max.

1. 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, micro-strip antennas have to face the narrow impedance bandwidth challenge.

A substrate (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 assilicon, 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 devices such as transistors, diodes, and especially integrated circuits (ICs) are deposited.

1.1 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.

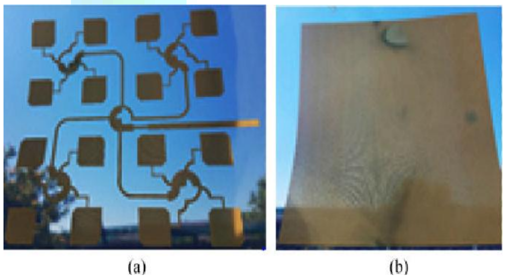


Fig 1.1. Inkjet-Printed Wideband Circularly Polarized Microstrip Patch Array Antenna on a PET Film Flexible Substrate Material

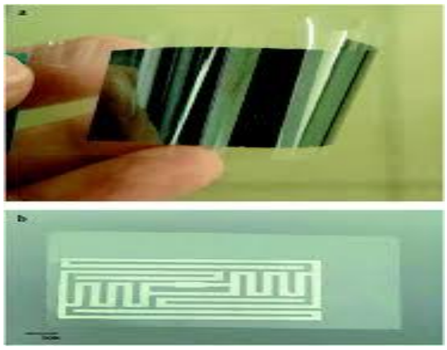


Fig 1.2. Photograph of inkjet printed silver patterns on PET substrate showing the metallic luster. (b) Inkjet printed silver ink based RFID antenna.

II. LITERATURE SURVEY

In this paper discuss the different flexible patch antenna and its different shapes. In the last few years the process of flexible technology is indomitable. There are different flexible antennas introduced by different researchers. In this survey discuss the different flexible antennas.

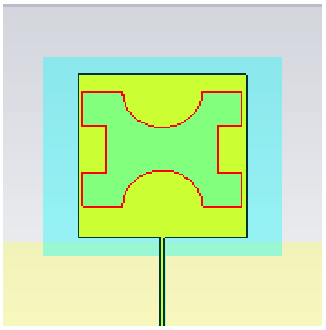
Amal Afyf et.al.[1]2020, In this research work author represent a flexible and body centric trans-receiver device for S band. The new structure improves on previous passive microwave imaging systems in that it is highly flexible, cost-effective to fabricate, and light-weight. Simulations were carried out with CST, exploiting a layered (inhomogeneous) model with different dielectric constants and loss tangents to capture the effect of surrounding tissues [1]. ***Wang, Chao, et.al. [2] 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 conformal RF devices. The presented antenna can be significantly deformed mechanically without much 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 [2]. ***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 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. 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 [03].***Kumari et.al. 2016*** In 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 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**[04].*****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 via on the PMMA substrate were enforced by introducing a unique stepped via whole configuration with an exponentially tapered radial profile[05]**.** ***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**[09].**

III.PROPOSED DESIGN

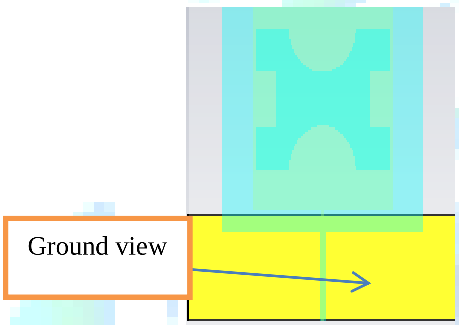
In this presented work shows the flexible antennas. These antennas have attracted considerable attention recently due to their potential advantage of low-cost, lightweight, reduced fabrication complexity, convenient integration, and conformability. The utilizationof the inexpensive flexible substrates (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.

Proposed Wide Multi Layer Microstrip Patch Antenna

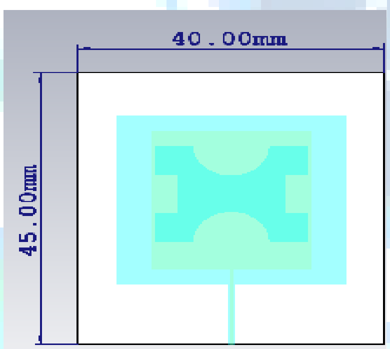
In the research work present a multilayer microstrip monopole fractal patch antenna for integration into flexible and conformal devices, it is good step for flexible technology. During this evolution two vital standards are Wi-MAX and Wireless local area network antennas are standard for its well-known engaging options, like a small size, easy to fabricate and easy to use.



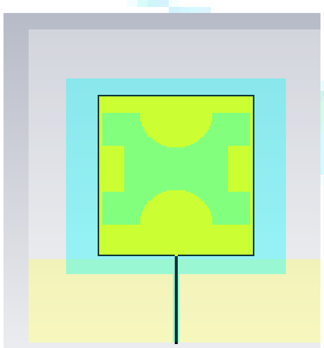
(a) Design of front view of multilayer microstrip monopole fractal patch antenna



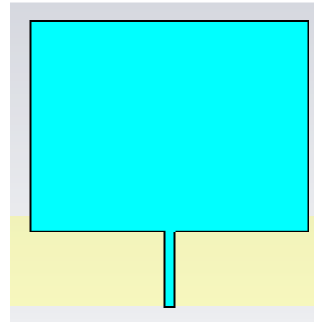
(b) Design of back end view



(c) Shows the dimension of substrate



(d) Shows the patch 1 (Copper based)



(e)Shows Patch 2 SU 8 based

Frequency of operation (f_0): The antenna resonance frequency must be chosen appropriately. Communication systems using the frequency range of 1 to 6 GHz at different wireless frequency range. The selected resonance frequency for proposed design is 1 to 6 GHz.

Di-electric constant of the substrate (εr): The di-electric constant of the substrate material plays an important role in the design of the patch antenna. So there is a compromise between size and performance of the patch antenna. In this thesis, use flexible Rogers RO4003Csubstrate with di-electric constant 3.38.

Height of di-electric substrate (*h*): The height of the di-electric substrate must be less. In this thesis substrate height is taken 1.6 mm.

To design a rectangular micro-strip patch antenna according to parameters such as di-electric constant (εr), the resonance frequency (f_o) and the height (h) are taken into consideration for the calculation of the length and width of the room.

Step 1: Calculation of Width (W)

For efficient radiator, the practical width which leads to a good radiation efficiency is:

$$W = \frac{c}{2fo\sqrt{\frac{\varepsilon r+1}{2}}} \qquad 1$$

Where c is the speed of the free area of the light.

Step 2: Di-electric Coefficient value calculation (ε reff)

The effectiveness of the di-electric constant (ε reff), using the same geometry (W h), but is surrounded by a homogeneous di-electric ε reff the effective permittivity whose value is determined by assessing the ability of the fringe field.

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2} \qquad 2$$

Step 3: Effective Length Design Equation (L eff)

$$Leff = \frac{c}{2fo\sqrt{\varepsilon reff}} \qquad 3$$

Step 4: Length Extension (ΔL) Design Equation

$$\frac{\Delta L}{h} = \frac{0.412(\varepsilon reff+0.3)(\frac{w}{h}+0.264)}{(\varepsilon reff-0.258)(\frac{w}{h}+0.8)} \quad 4$$

Step 5: Actual Length of Patch (L) Equation

The length of patch calculated by given below equation

$$L = Leff - 2\Delta L$$

Step 6: Ground Dimensions (Lg, Wg) Equation

The broadcast line model is applicable to infinite base surfaces solely. However, for sensible issues, it's essential to own a finite base surface. it's been shown by [6] that similar results to the finite base surface and eternity is also obtained if the scale of the bottom surface is bigger than the patch dimensions of regarding sixfold the thickness of the substrate all round the edge. Therefore, for this reason, the size of the bottom surface is given by:

$$L_g = 6h + W$$
$$W_g = 6h + L$$

Step 7: Calculation of width of the micro-strip feed line

Width of the micro-strip line is calculated by below equations

$$\frac{w}{h} = \left(\frac{exp(H')}{8} - \frac{1}{4\exp(H')}\right)^{-1}$$

$$H' = \frac{Z_0\sqrt{2(\varepsilon_r+1)}}{119.9} + \frac{1}{2}\left(\frac{\varepsilon_r-1}{\varepsilon_r+1}\right)\left(l_n\frac{\pi}{2} + \frac{1}{\varepsilon_r}l_n\frac{4}{\pi}\right)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2}\left[1 - \frac{1}{2H'}\left(\frac{\varepsilon_r-1}{\varepsilon_r+1}\right)\left(l_n\frac{\pi}{2} + \frac{1}{\varepsilon_r}l_n\frac{4}{\pi}\right)\right]^{-2}$$

Where er is di-electric constant, Zo is 50 ohm and h is 1.6mm.

Step 8 : Calculation of length of the micro-strip feed line

Free-space wavelength (λo):

λo = c / f

For the designing the bow tie antenna first require to design a simple patch antenna. After that apply different Boolean function of give the shape of bow Tie. In the below section discuss the evolution of proposed flexible bow tie antenna.

IV. SIMULATION AND RESULT

4.1 Introduction

Now discuss the simulation and result of the proposed antenna. In this proposed antenna different substrate technique as well as multi layer substrate are used for enhance the bandwidth , return loss (S-11)and other properties of antenna. The proposed multi layper mono pole patch antenna is design for Giga hertz (GHz)frequency range up to 6 GHz. The proposed frequency where this frequency range accommodate in the various band in between 1 GHz to 6 GHz in between the Wi-FI and Wi-Max range.

4.2 CST Design environment

Below the figure 4.1 shows the basic view of CST software. The proposed design in the CST 2016 version. The system for designing used is core i-5 4thG processor. The main part of proposed design is substrate (S), patch (P), ground (G) and feeding system (Waveguide feed). In this design using a wave guide wave port for feeding system. In general there are two type of feeding systems first one is wave guide port and second one is the wave guide port. Figure 4.1 and 4.2 shows the CST Design environment. In the below figure shows the design environment of proposed antenna .

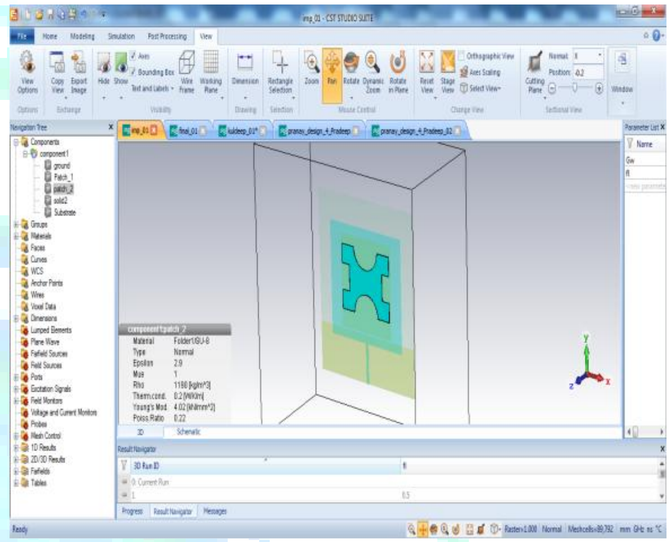


Fig 4.1 (a) Shows the front view of proposed design

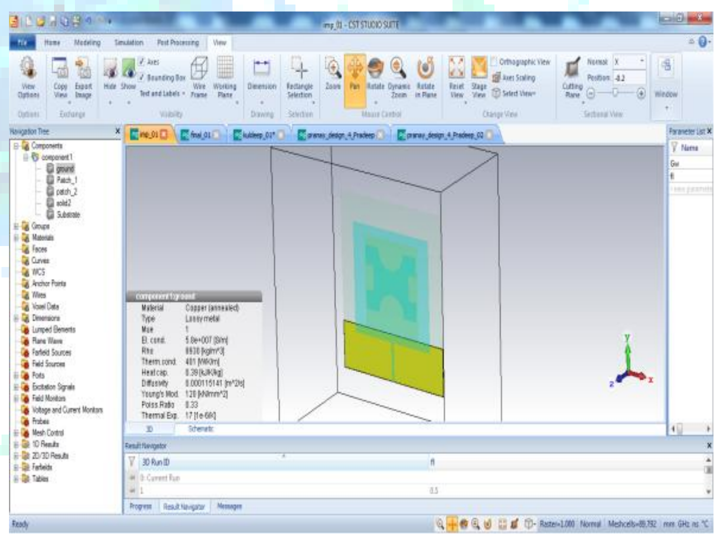


Fig 4.1 (b) Shows the Back view of proposed design (Ground)

4.3 Results of Proposed Design -I

This design II shows better performance as compare to design 2 that is discussed in the above section 4.4. The dimension and other parameters are already discussed in the previous section. 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.

4.3.1 Return Loss (S -11)

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

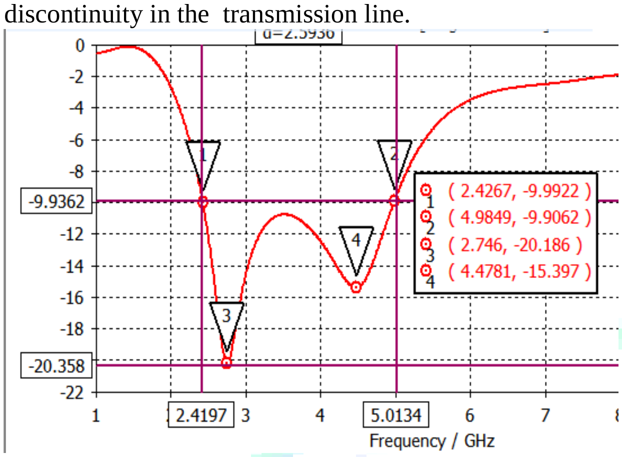


FIG. 4.2 RETURN LOSS (S-11) OF PROPOSED ANTENNA 2 (SINGLE WIDE BAND)

4.4.2 VSWR Parameter –

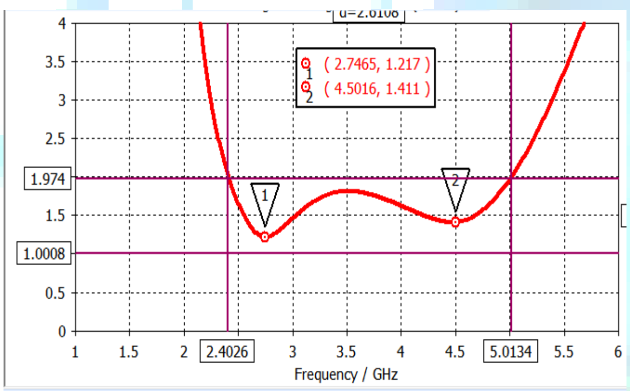


Fig. 4.3 shows the VSWR of proposed flexible bow tie antenna

4.4.3 Gain (G)

Below figure shows gain3D plot of proposed designs 1 antenna. The gain of proposed design 2.7 GHz near to 2.33dB. In the below figure 4.7 (a). 3-D figure of gain of proposed design.

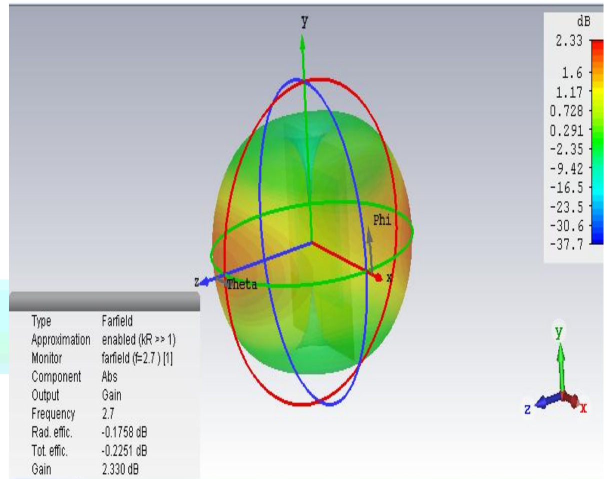


Fig. 4.4(a) 3-D diagram of proposed design (f =2.7 GHz)

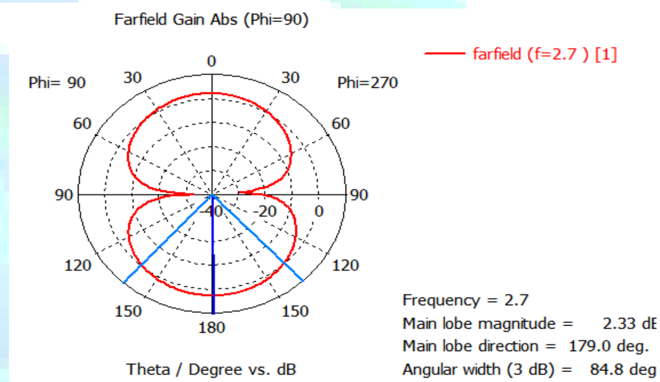
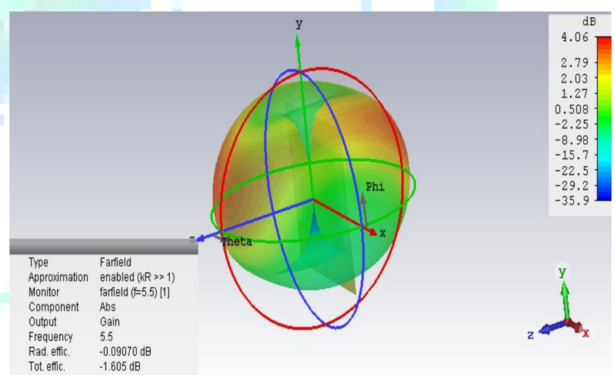


Fig. 4.3(b) Shows the far field pattern of proposed design(f =2.7 GHz)



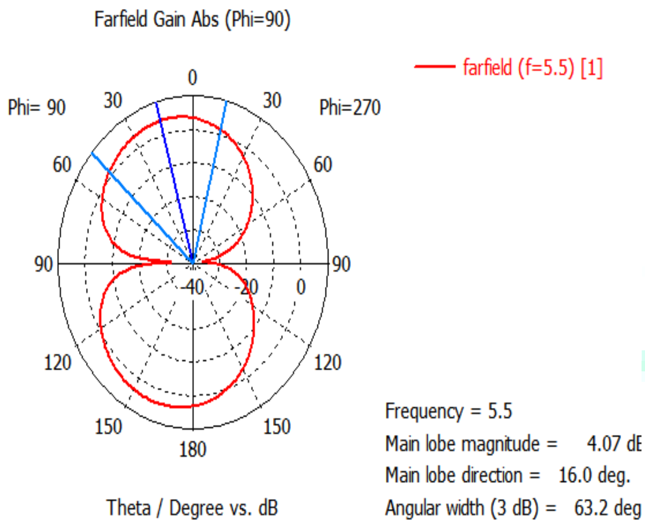


Fig. 4.5 (a) Shows the 3D pattern of proposed design (f =4.5 GHz)

V. CONCLUSION

The proposed designs very easily manufactured and it's fabrication from flexible Rogers RO4003C substrate for commercial use is convenient. Achieved gain over the range of bands is attractive feature for antenna. This designed radio is for high power, RF efficient radio equipped to transmit over band also compatible for OFDM & military purposes. These results shows antennas could be developed for possible applications in several wireless systems like WLAN, Wi-MAX if properly scale to the allowed frequency bands. As the Microstrip antenna is small in size so due to its compact size and compatibility with microwave devices more deserves to be a part of future modern communication system with much more accuracy, reliability and high performance.

REFERENCES

[1]. Muhamad, N. A., et al. "Polarization and Depolarization Current (PDC) tests on biodegradable and mineral transformer oils at different moisture levels." *2009 Australasian Universities Power Engineering Conference*. IEEE, 2009

[2]. Azis, Norhafiz, et al. "Suitability of palm based oil as dielectric insulating fluid in transformers." *Journal of Electrical Engineering & Technology* 9.2 (2014):

[3]. Jamail, N. A. M., M. A. M. Piah, and N. A. Muhamad. "Comparative study on conductivity using Polarization and Depolarization Current (PDC) test for HV insulation." *Proceedings of the 2011 International Conference on Electrical Engineering and Informatics*. IEEE, 2011

[4]. McShane, C. Patrick, et al. "Aging of paper insulation in natural ester dielectric fluid." *2001 IEEE/PES Transmission and Distribution Conference and Exposition. Developing New Perspectives (Cat. No. 01CH37294)*. Vol. 2. IEEE, 2001

[5]. Asano, Roberto, and Stephane A. Page. "Reducing environmental impact and improving safety and performance of power transformers with natural ester dielectric insulating fluids." *IEEE Transactions on Industry Applications* 50.1 (2013):

[6]. Liao, Ruijin, et al. "A comparative study of physicochemical, dielectric and thermal properties of pressboard insulation impregnated with natural ester and mineral oil." *IEEE Transactions on Dielectrics and Electrical Insulation* 18.5 (2011)

[7]. Ismail, Nazera, et al. "Effect of Water on Electrical Properties of Refined, Bleached, and Deodorized Palm Oil (RBDPO) as Electrical Insulating Material." *JurnalTeknologi* 64.4 (2013)

[8]. Hao, Jian, et al. "Quantitative analysis ageing status of natural ester-paper insulation and mineral oil-paper insulation by polarization/depolarization current." *IEEE Transactions on Dielectrics and Electrical Insulation* 19.1 (2012):

[9]. Martin, Daniel, and Z. D. Wang. "Statistical analysis of the AC breakdown voltages of ester based transformer oils." *IEEE Transactions on Dielectrics and Electrical Insulation* 15.4 (2008)

[10]. Rao, U. Mohan, Y. R. Sood, and R. K. Jarial. "Review on ester based dielectric liquids for transformer insulation technology." *2015 International Conference on Condition Assessment Techniques in Electrical Systems (CATCON)*. IEEE, 2015

[11]. Muhamad, N. A., B. T. Phung, and T. R. Blackburn. "Dissolved gas analysis of overheating fault in bio-degradable transformer oil." *2008 Australasian Universities Power Engineering Conference*. IEEE, 2008.

[12]. Muhamad, N. A., B. T. Phung, and T. R. Blackburn. "Dissolved gas analysis (DGA) of partial discharge fault in bio-degradable transformer insulation oil." *2007 Australasian Universities Power Engineering Conference*. IEEE, 2007.

[13]. Dumitran, Laurentiu Marius, Alexandra Ciuriuc, and Petru V. Notingher. "Thermal ageing effects on the dielectric properties and moisture content of vegetable and mineral oil used in power transformers." 2013 8th International Symposium On Advanced Topics In Electrical Engineering (Atee). Ieee, 2013.

[14]. Katim, NurulIzzatulAkma, et al. "Behavior of Biodegradable Oil under Impulse Voltages." *Applied Mechanics and Materials*. Vol. 785. Trans Tech Publications, 2015.

[15]. Kurnianto, Rudi, et al. "Breakdown strength of biodegradable dielectric liquid: The effect of temperature and viscosity." *2012 22nd Australasian Universities Power Engineering Conference (AUPEC)*. IEEE, 2012.

[16]. Azmi, Kiasatina, MohdAzmier Ahmad, and Mohamad KamarolMohd Jamil. "Study of dielectric properties of a potential RBD palm oil and RBD soybean oil mixture as insulating liquid in transformer." *Journal of Electrical Engineering & Technology*10.5 (2015): 2105-2119.

[17]. Liao, Ruijin, et al. "A comparative study of physicochemical, dielectric and thermal properties of

pressboard insulation impregnated with natural ester and mineral oil." *IEEE Transactions on Dielectrics and Electrical Insulation* 18.5 (2011): 1626-1637.
[18]. Ab Ghani, Sharin, et al. "Methods for improving the workability of natural ester insulating oils in power transformer applications: A review." *Electric Power Systems Research* 163 (2018): 655-667.
[19]. Henshaw, U. T., M. A. Usman, and O. O. Olanipekun. "A comparative study of soya bean oil and palm kernel oil as alternatives to transformer oil." *Journal of Emerging Trends in Engineering and Applied Sciences* 3.1 (2012): 33-37.
[20]. Hosier, Ian L., Alun S. Vaughan, and Steve G. Swingler. "Studies on the ageing behavior of various synthetic and natural insulation oils." *2008 IEEE International Conference on Dielectric Liquids*. IEEE, 2008.
[21]. Muhamad, N. A., et al. "Dissolved gas analysis of faults in biodegradable oil transformer insulating systems." 2008 International Conference on Condition Monitoring and Diagnosis. IEEE, 2008.
[22]. Ilyas, M. "Effects of temperature on dielectric properties of rhicinnus oils as insulating liquid."*2008 International Conference on Condition Monitoring and Diagnosis*. IEEE, 2008.
[23]. Perrier, Christophe, and AbderrahmaneBeroual. "Experimental investigations on mineral and ester oils for power transformers."*Conference Record of the 2008 IEEE International Symposium on Electrical Insulation*. IEEE, 2008.
[24]. Prosr, Pavel, et al. "Influence of oil type on the oil-paper insulation properties."*2007 Annual Report-Conference on Electrical Insulation and Dielectric Phenomena*. IEEE, 2007.
[25]. Li, Jian, et al. "Dielectric properties of rapeseed oil paper insulation."*2007 Annual Report-Conference on Electrical Insulation and Dielectric Phenomena*. IEEE, 2007.
[26]. Muhamad, N. A., B. T. Phung, and T. R. Blackburn. "Dissolved gas analysis (DGA) of partial discharge fault in bio-degradable transformer insulation oil."*2007 Australasian Universities Power Engineering Conference*. IEEE, 2007.
[27]. Oommen, T. V., and Thomas A. Prevost. "Cellulose insulation in oil-filled power transformers: part II maintaining insulation integrity and life."*IEEE Electrical Insulation Magazine* 22.2 (2006): 5-14.
[28]. Sun, Caixin, et al. "Electric properties of vegetable oil-based dielectric liquid and lifetime estimation of the oil-paper insulation."*2006 IEEE Conference on Electrical Insulation and Dielectric Phenomena*. IEEE, 2006.
[29]. Ruijin, Liao, et al. "Thermal aging studies on cellulose insulation paper of power transformer using AFM."*2006 IEEE 8th International Conference on Properties & applications of Dielectric Materials*. IEEE, 2006.
[30]. Martin, D., and Z. D. Wang. "A comparative study of the impact of moisture on the dielectric capability of esters for large power transformers."*2006 IEEE Conference on Electrical Insulation and Dielectric Phenomena*. IEEE, 2006.

