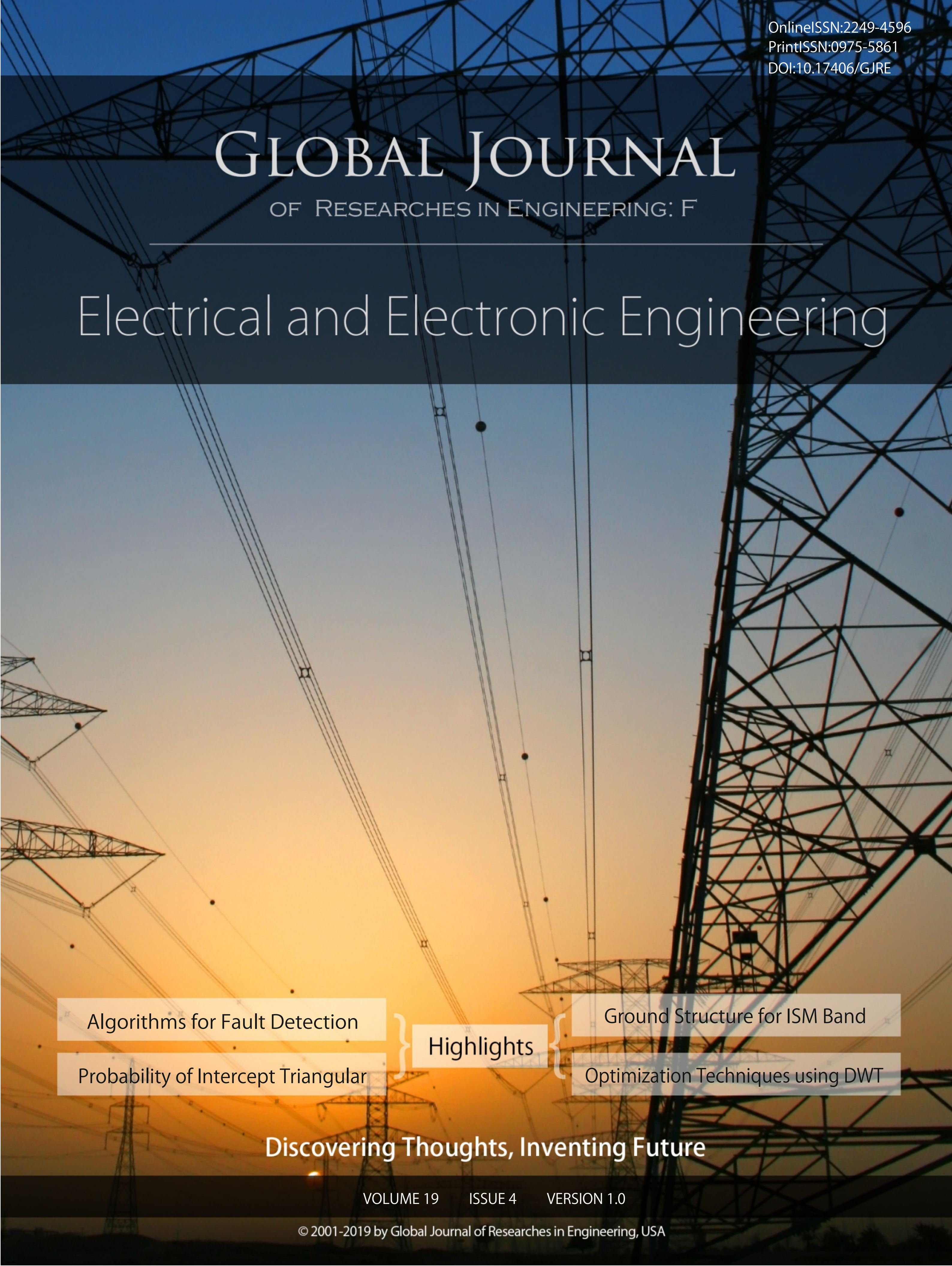


Online ISSN:2249-4596
Print ISSN:0975-5861
DOI:10.17406/GJRE

Global Journal

of Researches in Engineering: F

Electrical and Electronic Engineering

Algorithms for Fault Detection

Probability of Intercept Triangular

Highlights

Ground Structure for ISM Band

Optimization Techniques using DWT

Discovering Thoughts, Inventing Future

VOLUME 19 ISSUE 4 VERSION 1.0

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering

Volume 19 Issue 4 (Ver. 1.0)

Open Association of Research Society

Incorporation No.: 0423089
License No.: 42125/022010/1186
Registration No.: 430374
Import-Export Code: 1109007027
Employer Identification Number (EIN):
USA Tax ID: 98-0673427

Global Journals Inc.

*(A Delaware USA Incorporation with "Good Standing"; **Reg. Number: 0423089**)*

Sponsors: *Open Association of Research Society*
Open Scientific Standards

Publisher's Headquarters office

Global Journals® Headquarters
945th Concord Streets,
Framingham Massachusetts Pin: 01701,
United States of America
USA Toll Free: +001-888-839-7392
USA Toll Free Fax: +001-888-839-7392

Offset Typesetting

Global Journals Incorporated
2nd, Lansdowne, Lansdowne Rd., Croydon-Surrey,
Pin: CR9 2ER, United Kingdom

Packaging & Continental Dispatching

Global Journals Pvt Ltd
E-3130 Sudama Nagar, Near Gopur Square,
Indore, M.P., Pin:452009, India

Find a correspondence nodal officer near you

To find nodal officer of your country, please email us at *local@globaljournals.org*

eContacts

Press Inquiries: *press@globaljournals.org*
Investor Inquiries: *investors@globaljournals.org*
Technical Support: *technology@globaljournals.org*
Media & Releases: *media@globaljournals.org*

Pricing (Excluding Air Parcel Charges):

Yearly Subscription (Personal & Institutional)
250 USD (B/W) & 350 USD (Color)

Diego Gonzalez-Aguilera

Ph.D. Dep. Cartographic and Land Engineering, University of Salamanca, Avilla, Spain

Contents of the Issue

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 19 Issue 4 Version 1.0 Year 2019
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Design and Fabrication of Miniaturized Dual-Band Antenna using Split-Ring & Defected Ground Structure for ISM Band Applications

By Stuti Neha, Lavesh Gupta & Dr. Arun Dev Dhar Dwivedi
Poornima University Jaipur

Abstract- In this paper the design and fabrication of a miniaturized dual band antenna using split ring and modified ground structure for the application of ISM band has been presented. The designed antenna consists of number of slots on patch which forms a split ring, one substrate layer and a common ground plane which is modified accordingly to obtain the desired resonant frequency. The proposed configuration gives a general size diminishment by doing modification in the ground plane. Due to modified ground, efficiency of an antenna is increased. The proposed antenna is designed to operate at 2.45GHz and 5.8GHz. It achieves a return loss of -34.6dB at 2.45GHz and -38.1dB at 5.8GHz. Proposed Antenna has many practical applications like in ISM, WIFI, commercial business, Bluetooth, cordless phone. Voice, video and data communication also uses this frequency band. It is designed with the help of CST microwave studio 2011 software. Same antenna is fabricated and testing has been done. In this paper we have shown the comparison of simulated results and experimental results.

Keywords: *microstrip patch antenna, ISM band, design and fabrication.*

GJRE-F Classification: *FOR Code: 090609*

DESIGNANDFABRICATIONOFMINIATURIZEDDUALBANDANTENNAUSINGSPLITRINGDEFECTEDGROUNDSTRUCTUREFORISMBANDAPPLICATIONS

Design and Fabrication of Miniaturized Dual-Band Antenna using Split-Ring & Defected Ground Structure for ISM Band Applications

Stuti Neha [α], Lavesh Gupta [σ] & Dr. Arun Dev Dhar Dwivedi [ρ]

Abstract- In this paper the design and fabrication of a miniaturized dual band antenna using split ring and modified ground structure for the application of ISM band has been presented. The designed antenna consists of number of slots on patch which forms a split ring, one substrate layer and a common ground plane which is modified accordingly to obtain the desired resonant frequency. The proposed configuration gives a general size diminishment by doing modification in the ground plane. Due to modified ground, efficiency of an antenna is increased. The proposed antenna is designed to operate at 2.45GHz and 5.8GHz. It achieves a return loss of -34.6dB at 2.45GHz and -38.1dB at 5.8GHz. Proposed Antenna has many practical applications like in ISM, WIFI, commercial business, Bluetooth, cordless phone. Voice, video and data communication also uses this frequency band. It is designed with the help of CST microwave studio 2011 software. Same antenna is fabricated and testing has been done. In this paper we have shown the comparison of simulated results and experimental results.

Keywords: microstrip patch antenna, ISM band, design and fabrication.

I. Introduction

Wireless communication was introduced in 19th century. It has progressed toward becoming fastest growing sector of communication area. In wireless communication data is transmitted and received without using cables and wires. The wireless innovation has changed from analog first generation communication system and is about to an advanced fifth generation. Nowadays, the wireless communication innovation is facing the expanding interest of high transmission data rate, scalability, and efficiency.[1-3] In 1897, Marconi was the first scientist to exhibit that it was conceivable to set up a ceaseless correspondence stream with boats that were cruising forward, the remote innovations that, make progressing correspondence workable for us have been developed strikingly[4-5].

Wireless systems are playing a very important role in industries, medical, and in scientific field. The new age of cost-effective wireless communication innovation has been driven by relatively bringing down equipment and software cost and low power utilization [6-8]. However, these wireless technologies and remote advances have generally low information rate and perform its operation within a closed wireless communication network. These wireless technologies or we can say remote innovations operate or work inside extensive variety of frequency bands called as the ISM radio band [9-11]. ISM refers to Industrial, Scientific, and Medical radio band which are saved for the utilization of industries, scientific, and medical requirements. These frequency bands are unlicensed because it can be exploited according to different regions, by any person. ISM band are accepted band for worldwide operations. The bands which are mostly used are 2.45 GHz, 915 MHz, 868 MHz, and 433.92 MHz in the sward of Internet of Things and home [12-14]. In numerous research papers, antenna was outlined and manufactured to fulfill the coveted outcomes and working recurrence. There were numerous issues and disadvantages of the composed antenna. Some of the issues are antenna large size, its manufacturing cost; one antenna can be connected for just a single application [15-18] etc. To overcome the problem of expansive size of an antenna, applicable for more than one application, dual band antenna, which enhances the conventional patch antenna is required. In this paper the design and fabrication of a miniaturized dual band antenna using split ring and modified ground structure for ISM band application has been presented. We have shown the comparison of simulated results and experimental results.

II. Antenna Design

An efficient technique to build the antenna of large bandwidth is the use of modified ground plane. To include the applications of ISM as a modified ground plane strategy a rectangular patch and a narrow slit is made in the ground plane. In this outline of antenna a ground plane of patch antenna some surrendered shape is presented and relying upon the distinctive measurement, shape, and size of the defect (slots) the shielded current appropriation will get exasperate. The principle point of the proposed work is to upgrade and improve the conventional rectangular patch antenna performance at 2.45 GHz and 5.8 GHz frequency band

Author α: M. Tech Scholar, Digital Communication, Poornima University, Jaipur, Rajasthan, India.
Author σ: Phd Scholar, Department of EEE, Poornima University, Jaipur, Rajasthan, India. e-mail: laveshgupta5@gmail.com
Author ρ: Professor, Department of EEE, Poornima University, Jaipur. Rajasthan, India. e-mail: adddwivedi@gmail.com

for ISM applications using split ring and modified ground structure. The material utilized for substrate is FR-4 lossy, for ground, and for patch PEC (pure electric conductor) material is used. The parameters of ground, patch and substrate of the proposed receiving wire are calculated using the mathematical formulas of micro strip patch antenna. Fig.1 shows the structure of the proposed antenna and Fig.2 shows the simulated structure of the antenna.

Step 1: Calculation of Width (W)

For an efficient radiator, practical width that leads to good radiation efficiencies is given by:

$$W = \frac{1}{2fr\sqrt{\mu o \varepsilon o}}\sqrt{\frac{2}{\varepsilon r+1}} \qquad [1]$$

Step 2: Calculation of effective dielectric coefficient (ε_r):

The effective dielectric constant is given by:

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

Step 3: Calculation of effective Length (Leff):

$$Leff = \frac{c}{2f0\sqrt{\varepsilon reff}} \qquad [3]$$

Step 4: Calculation of Length Extension (L):

Before the calculation of "L", ΔL will be calculated by

$$\Delta L = 0.412\,\frac{(\varepsilon reff+0.3)(\frac{W}{h}+0.264)}{(\varepsilon reff-0.258)(\frac{W}{h}+0.8)} \qquad [4]$$

Step 5: Calculation of actual length of patch (L):

Thus, the actual length of the radiating patch is obtained by

$$L = Leff - 2\Delta L \qquad [5]$$

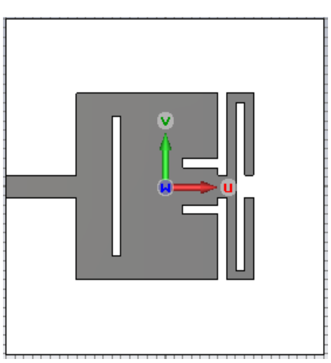
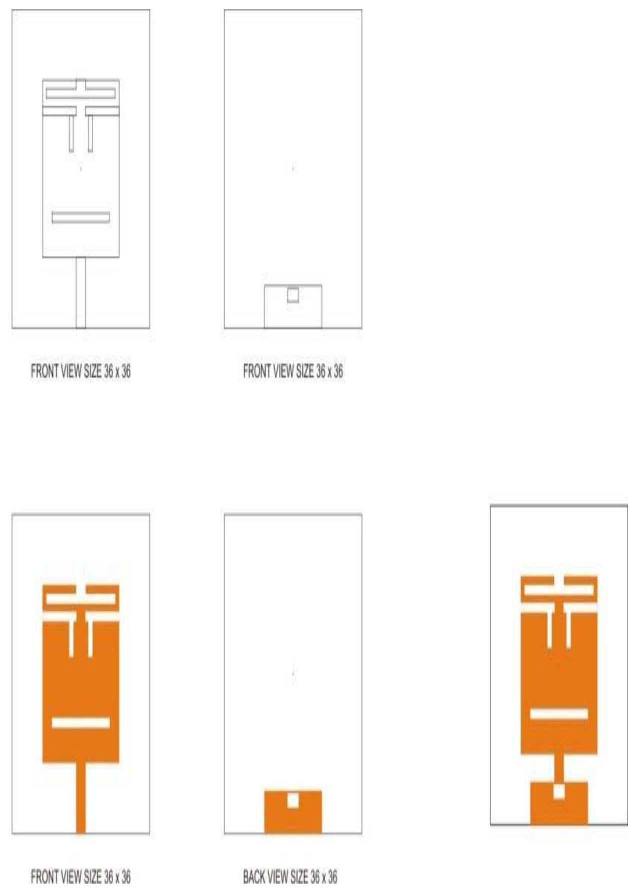


Fig. 1: Proposed design of microstrip antenna

Table 1: Dimensions of designed antenna.

Parameters	Dimension in mm
Width and length of substrate	36 x 36 mm
Dielectric constant	4.3
Material of substrate	FR4
Length and width of ground	36 x 36 mm
Length of modified ground	31.2 mm
Width of modified ground	15 mm
Length of slot in ground(solid 1)	28 mm
Width of slot in ground (solid 1)	2.8 mm
Length of feed line	28 mm
Width of feed line	2.4 mm
Length of slot 1 in patch	15 mm
Width of slot 1 in patch	11 mm



Design parameters were calculated using design equations given from (1) to (5) and listed in Table-1 which were used in simulation.

a) Measured And Simulated Results

i. Return loss and Antenna Bandwidth

The measured and simulated return loss characteristics are shown in Fig. 3 (a) and (b) representing that the proposed antenna shows a return loss of -16dB at 2.45GHz and -23.98 dB at 5.8GHz which is a good agreement.

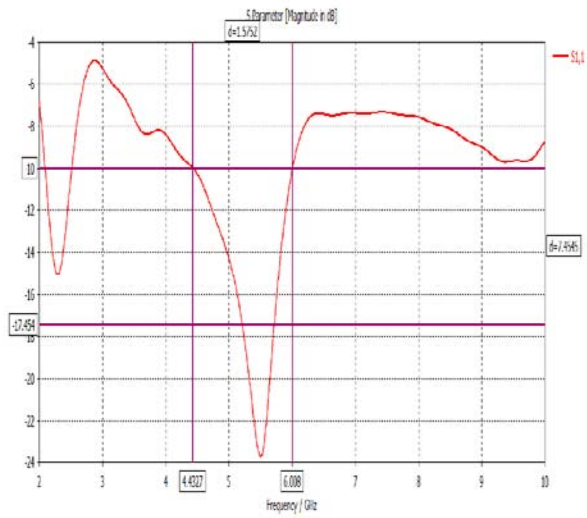


Fig. 3(a): Return loss curve for 2.45GHz

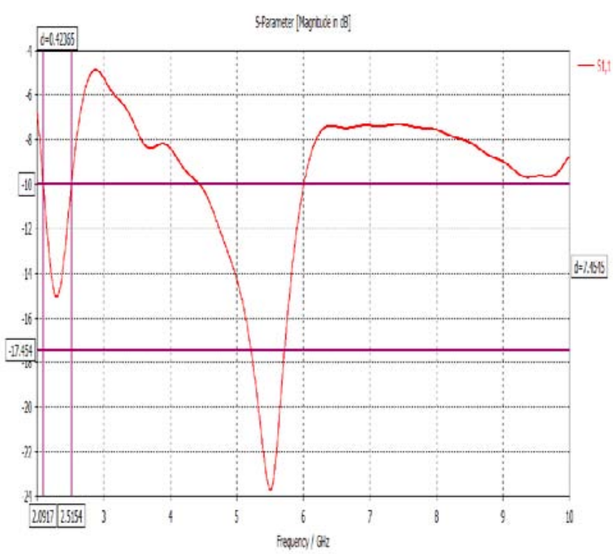


Fig. 3 (b): Return loss curve for 5.8GHz

The antenna resonates from 2.0917GHz - 2.5154GHz with center frequency 2.45GHz and 4.4327GHz -6.008GHz with center frequency 5.8 GHz as shown in Fig. 3(a) and Fig. 3(b) which is pertinent for application in ISM.

b) Directivity

Directivity measures the aggregate amount of energy which is radiated from antenna in a particular course, in fact the maximum radiated energy. Generally directivity is always greater than 1 but on account of an isotropic antenna which is having directivity equivalent to 1. An antenna which is having directivity equivalent to 1 is called directive antenna. This antenna design gives the directivity at frequency 2.45GHz as shown in Fig. 4(a) represents amount of radiation force. The design gives the directivity of 2.343 dbi at 2.45GHz as appeared in the Fig. 4(b) and 4.946 dBi at 5.8GHz as appeared in the Fig. 4(c). The simulated results of directivity are shown below.

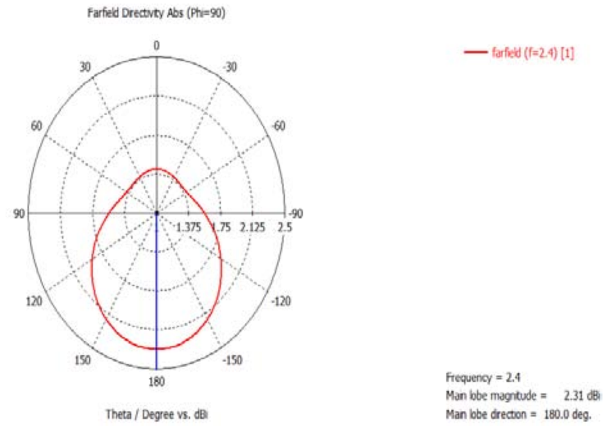


Fig. 4(a): Directivity plot at 2.45 GHz

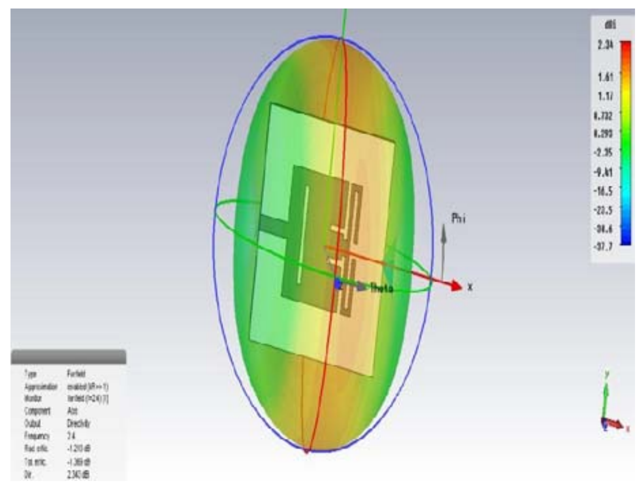


Fig. 4(b): 3D Directivity Plot at 2.45GHz

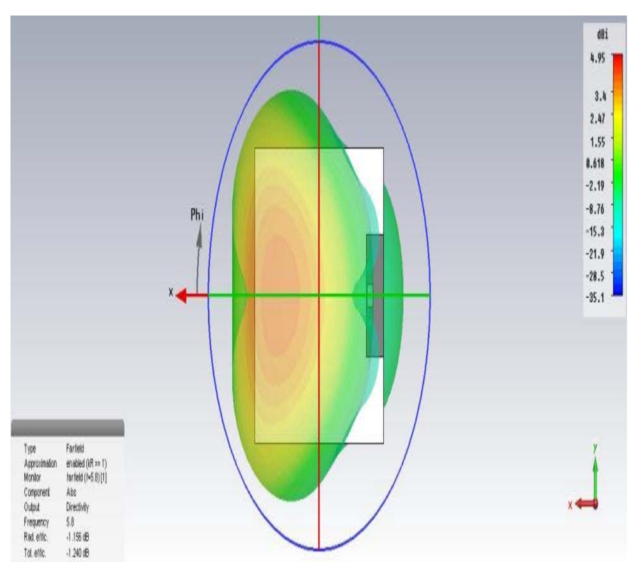


Fig. 4(c): 3D Directivity plot at 5.8 GHz

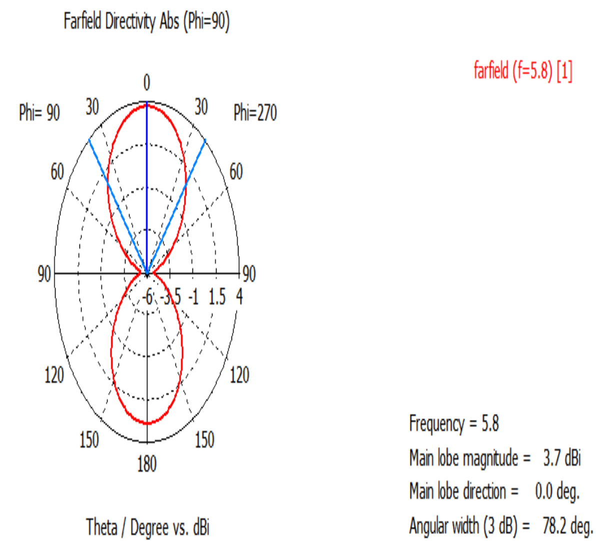


Fig. 4(d): Directivity plot at 5.8 GHz

Fig. 4(b) and Fig. 4(c) is a plot of 3D directivity of a proposed antenna. The directivity of an antenna at 5.8GHz is 4.946 dBi. The antenna radiates in specific direction as shown in the plot.

c) Gain

Ratio of intensity in a given direction to the radiation power that would be achieved from it if power is radiated by the antenna isotropically. The simulation outcomes of the gain are shown below and the gain obtained is 1.13dB at 2.45 GHz and 3.685dB at 5.8GHz.

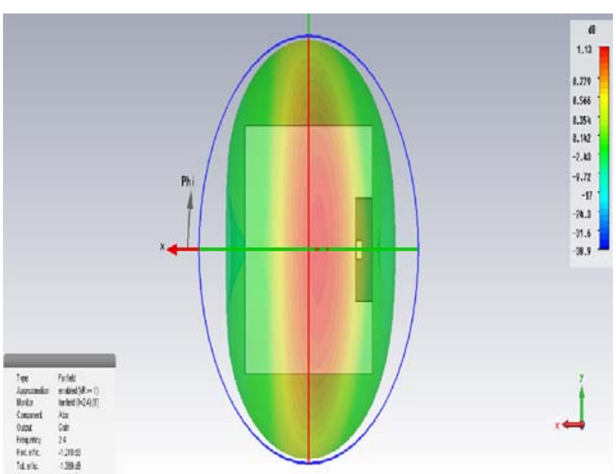


Fig. 5(a): 3D Gain at 2.45 GHz

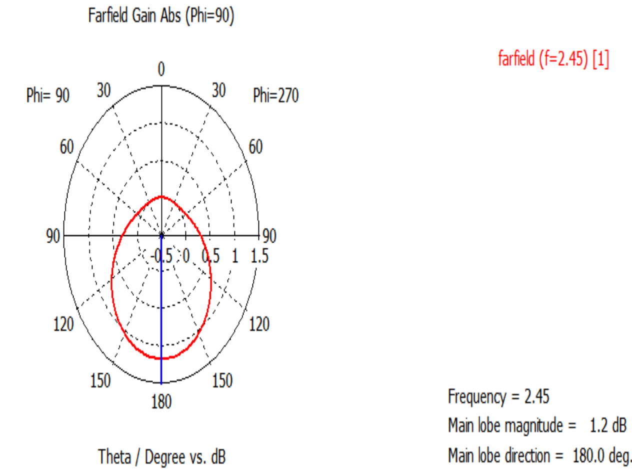


Fig. 5(b): Gain at 2.45GHz

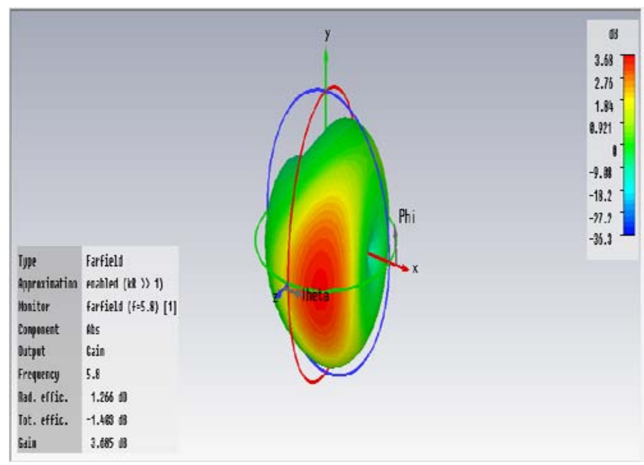


Fig. 5(c): 3D Gain at 5.8GHz

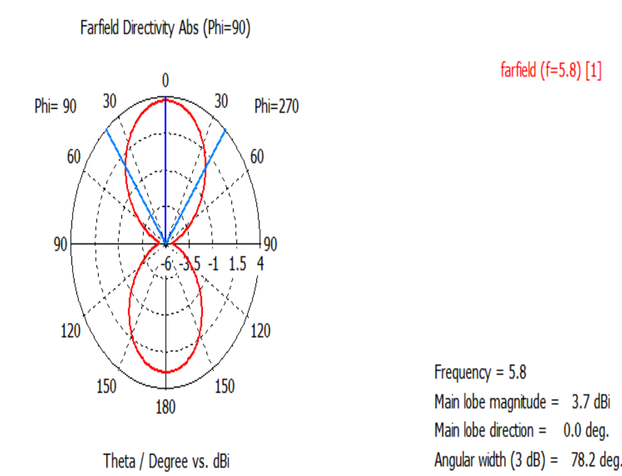


Fig. 5(d): Gain at 5.8GHz

d) Voltage standing Wave Ratio

This parameter is used for matching and tuning of the transmitting antennas. It defines how well the antenna is matched with the transmission line it is associated with. Fig. 6(a) and (b) is representing the value of VSWR lies b/w 1 & 2.

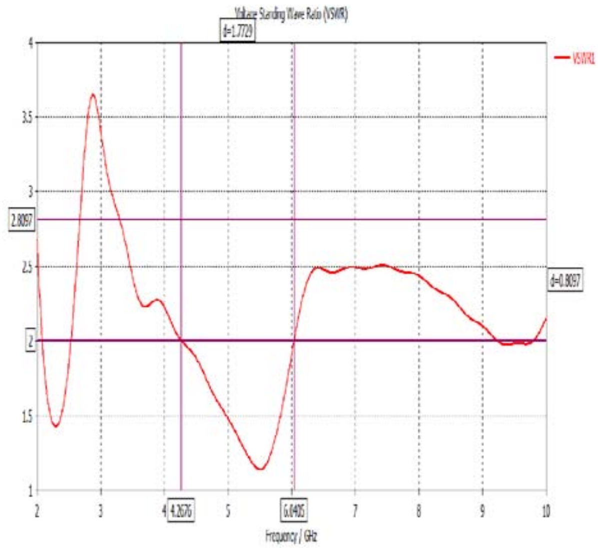


Fig. 6(a): VSWR lies between 1-2 at 2.45 GHz

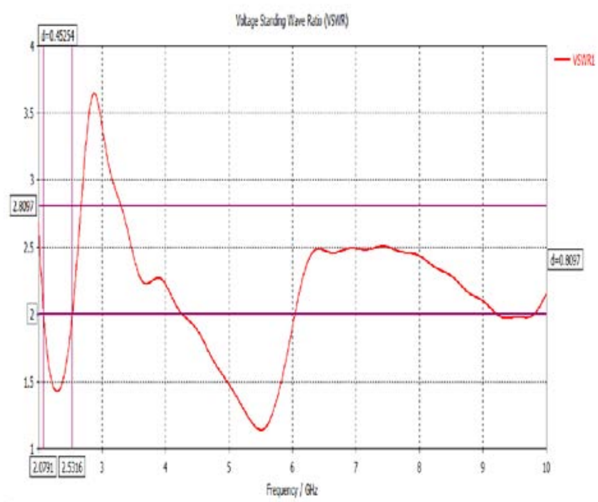
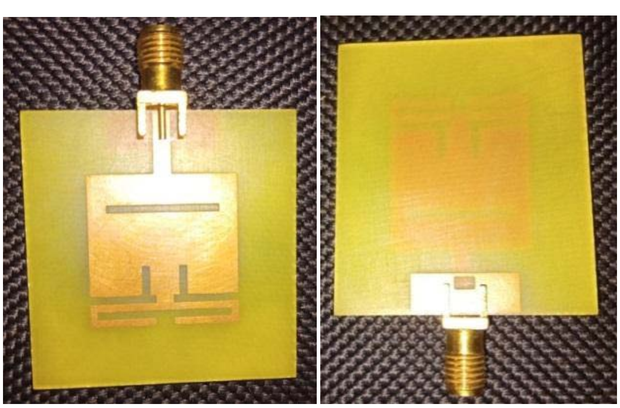


Fig. 6(b): VSWR of proposed antenna at 2.45 & 5.8GHz



(a) (b)

Fig. 7(a): Fabricated antenna front view and (b) Fabricated antenna back view

The proposed antenna resonates from 2.0917 GHz -2.5154 GHz which is covering the bandwidth range 2.4GHz-2.5GHz with center frequency 2.45 GHz and 4.4327 GHz -6.008GHz covering the bandwidth range 5.75GHz-5.875GHz with center frequency 5.8 GHz which is applicable for application in ISM as shown in the above figures. The S11 parameters of fabricated antenna are shown above which are tested in vector network analyzer at resonant frequency of 2.41 and 5.89GHz.

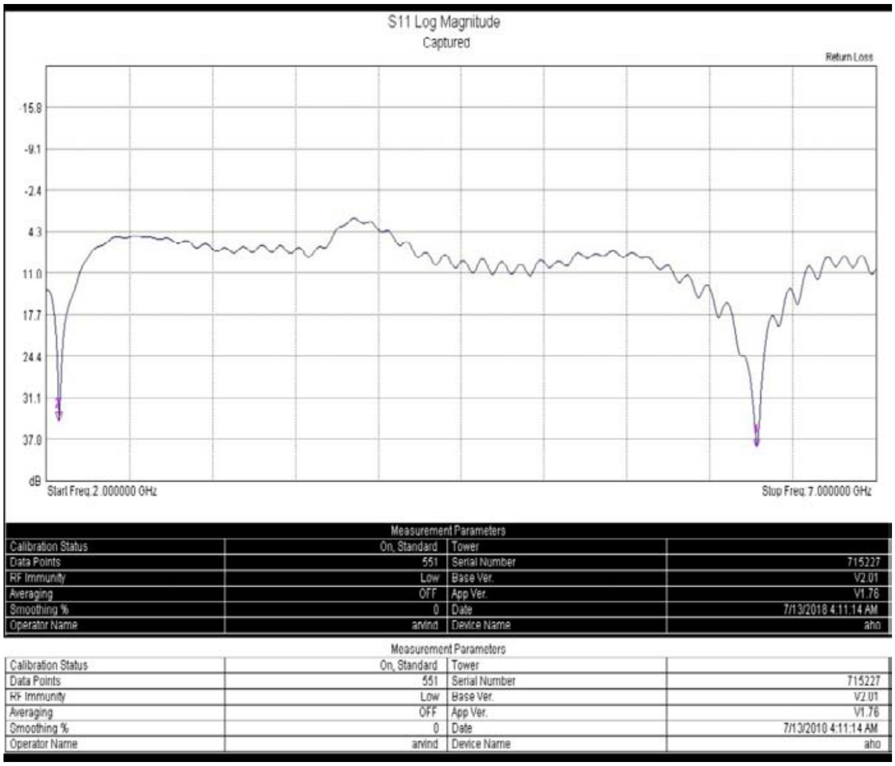


Fig. 8: S11 parameter of fabricated antenna, tested in VNA

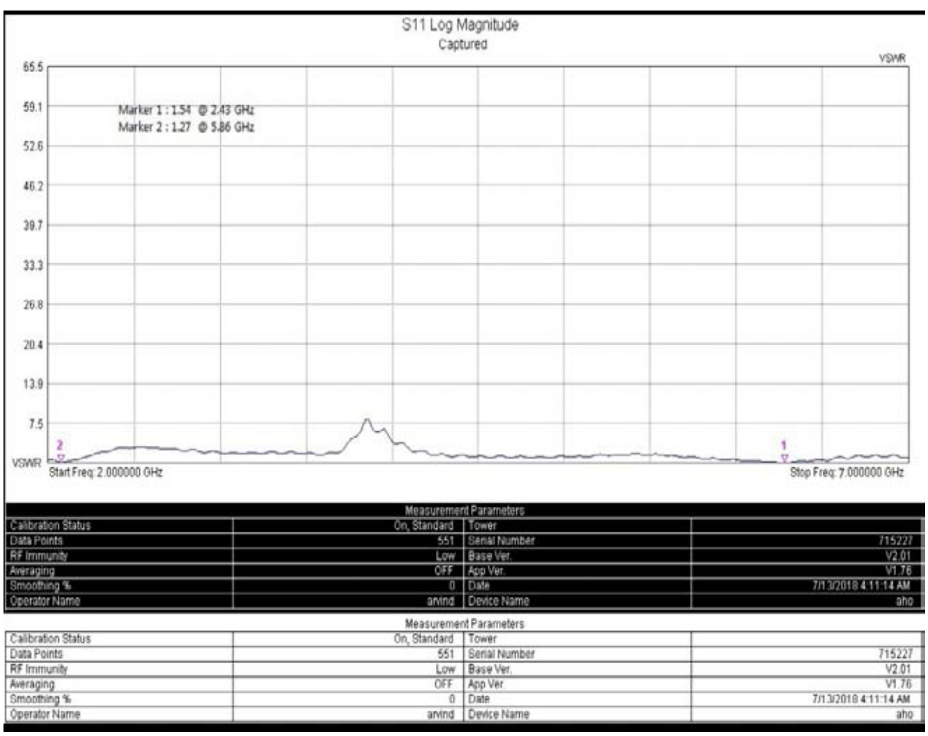
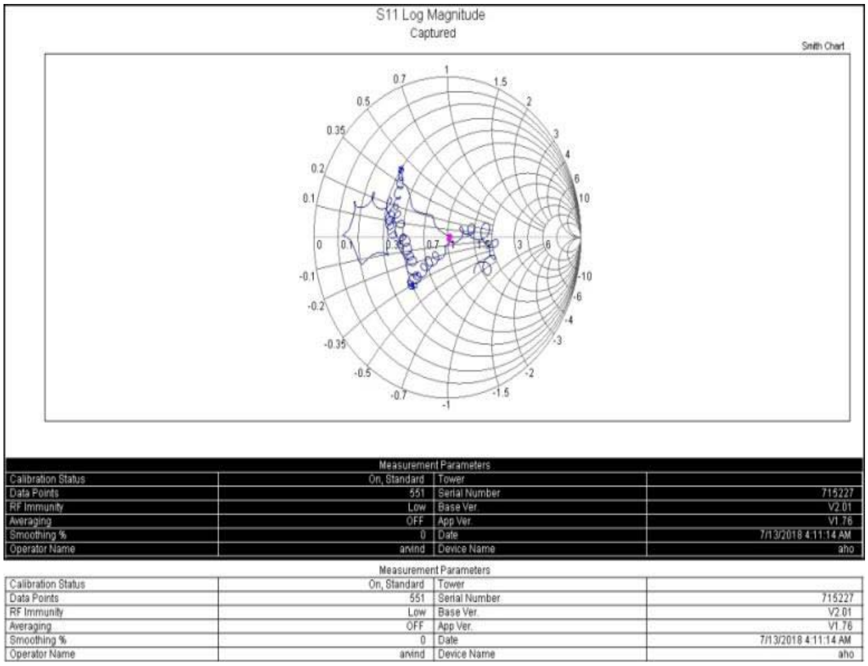


Fig. 9: VSWR of fabricated antenna

It is used for matching and tuning of the transmitting antennas. It defines how well the antenna is matched with the transmission line it is associated with. Ideally, VSWR values should recline in the range of 1 and 2 which has been achieved for 2.41GHz and 5.89GHz frequency, near the operating frequency value. The VSWR ratio of 2.41GHz and 5.89GHz frequencies is 1.54 and 1.27 respectively. Smith chart speaks that how the receiving wire impedance differs with recurrence.



III. Comparison Table

Table 2: Comparison table of Experimental and simulated results

Parameter	Simulation Results	Experimental Results
Bandwidth 1	2.03GHz-2.49GHz	2.41GHz
Bandwidth 2	4.45GHz-6GHz	5.89GHz
Voltage Standing Wave Ratio 2.4GHz	1.46	1.54
Voltage Standing Wave Ratio at 5.8GHz	1.23	1.27
Return Loss at 2.45GHz	-16.75dB	-34.6dB
Return Loss at 5.8GHz	-23.98dB	-38.1dB

The above table is about the examination of recreated result and the testing result. The deliberate and mimicked return loss qualities of the preferred antenna are appeared in Fig.4. These are -16.75dB and in case of experimental result it is -34.6dB at 2.45GHz, at 5.8GHz expected return loss is -23.98dB and in case of experimental result it is -38.1dB. The bandwidth got amid the reenactment of an antenna in CST programming first bandwidth range got is 2.03-2.49GHz and second bandwidth range got is 4.45-6GHz which is covering the frequency range of ISM. While manufactured antenna gives recurrence of 2.41GHz and 5.89GHz. Simulation process is giving VSWR range in between 1 and 2 at dual frequency and experimental result is giving VSWR of 1.54 at 2.45GHz and 1.27 at 5.8GHz. By contrasting the aftereffects of recreation process and exploratory process we can infer that exploratory outcomes are far superior to simulation result.

IV. Conclusion

In light of the conclusions, results, and limitations of the proposed work, future work can be completed are as follows: In the antenna designed with split ring and modified ground. There are various unsolved issues and to be tended later on for further improvement in this specific area. The advancement which should be possible includes minimization of unwanted leakage of radiation through the modified ground and this should be possible by adjusting the shape, structure or reconfiguring the shape of antenna. Optimization of modified ground can be done to evade clashes with radiating mode. In future diodes can also be utilized or placed in slots to perform the antenna at a particular frequency band for specific applications, just by switching on and off the diodes. By using extraordinary and unique configuration of structure, using different material of dielectric substrate the work can be expanding in this work. In future different slots on the ground and on patch can be designed for getting better and different result. Structure of patch can also be changed according to get better result. Firstly a miniaturized dual band antenna with split ring and modified ground structure has been designed for the Industrial, scientific and medical applications. The various parameters like return loss, VSWR, directivity, gain, bandwidth and operating frequency are studied for antenna designing. Initially, the work starts with the designing of simple patch antenna with a single slot in ground to obtain center frequency of 2.45GHz frequency. Modification is done in ground's dimensions that are in width and in its length. The next step is to design split ring on the patch which gives center frequency of 5.8 GHz. It is also concluded that physical parameters like resonate length and width of slot in ground effects the results of the antenna. It can be clearly seen that varying dimensions like length, width of respective substrate, patch, and ground in the right way gives optimized results for desired results.

References Références Referencias

1. X. Ding and A. F. Jacob, "CPW-fed slot antenna with wide radiating apertures," in *IEE Proceedings - Microwaves, Antennas and Propagation*, vol. 145, no. 1, pp. 104-108, Feb. 1998.doi: 10.1049/ip-map: 19981629.
2. Horng-Dean Chen, "Broadband CPW-fed square slot antennas with a widened tuning stub," in *IEEE Transactions on Antennas and Propagation*, vol. 51, no. 8, pp. 1982-1986, Aug. 2003.doi: 10.1109/TAP.2003.814747.
3. C. B. Ravipati, "Compact circular microstrip antenna for conical patterns," *IEEE Antennas and Propagation Society Symposium, 2004.*, Monterey, CA, USA, 2004, pp. 38203823Vol. 4. doi: 10.1109 /APS. 2004. 1330181.
4. U. Bhobe, C. L. Holloway, M. Piket-May and R. Hall, "Wide-band slot antennas with CPW feed lines: hybrid and log-periodic designs," in *IEEE Transactions on Antennas and Propagation*, vol. 52, no. 10, pp. 2545-2554, Oct. 2004.doi: 10.1109/TAP.2004.834425.
5. P. Sarin, N. Nassar, V. Deepu, C. K. Aanandan, P. Mohanan and K. Vasudevan, "Wideband Printed Microstrip Antenna for Wireless Communications," in *IEEE Antennas and Wireless Propagation Letters*, vol. 8, pp. 779781, 2009. doi: 10. 1109/LAWP. 2009. 2026193.
6. A. Dastranj and H. Abiri, "Bandwidth Enhancement of Printed E-Shaped Slot Antennas Fed by CPW and Microstrip Line," in *IEEE Transactions on Antennas and Propagation*, vol. 58, no. 4, pp. 1402-1407, April 2010.doi: 10.1109/TAP.2010.2041164.
7. Anuj Y.Modi, Jigar Mehta, Nilima Pisharody, "Synthesis of Elliptical Patch Microstrip Antenna Using Artificial Neural Network". 2013 IEEE
8. S. E. Mendhe and Y. P. Kosta, "Ultra wide band three layer microstrip patch antenna using single layer helical resonating metamaterial cover,"*2013 Tenth International Conference on Wireless and Optical Communications Networks (WOCN)*, Bhopal, 2013, pp. 1-5.doi: 10.1109/WOCN.2013.6616250.
9. S. Roy, P. B. Saha and M. Bhowmik, "Rectangular patch antenna for wireless LAN frequency with periodic DGS structure,"*2015 International Conference on Communications and Signal Processing (ICCSP)*, Melmaruvathur, 2015, pp. 1080-1082.doi: 10.1109/ICCSP.2015.7322667.
10. Krishna, D. D., M. Gopikrishna, C. K. Aanandan, P. Mohanan, and K. Vasudevan, "Compact dual band slot loaded circular mi-crostrip antenna with a superstrate," *Progress In Electromagnetics Research*, PIER 83, 245–255, 2008.
11. S. Kannadhasan and A. C. Shagar, "Design and analysis of U-Shaped micro strip patch antenna,"*2017 Third International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB)*, Chennai, 2017, pp. 367-370.doi: 10.1109/AEEICB.2017.7972333.
12. Jyh-Ying Chiou, Jia-Yi Sze and Kin-Lu Wong, "A broad-band CPW-fed strip-loaded square slot antenna," in *IEEE Transactions on Antennas and Propagation*, vol. 51, no. 4, pp. 719-721, April 2003.doi: 10.1109/TAP.2003.812232.
13. Chulvanich C., Nakasuwan J., Songthanapitak N., Ansntrasirichai N. and T. Wakabayashi (2007); "Design of narrow slot antenna for dual frequency," *PIERS Online*, Vol. 3, No. 7, pp. 1024–1028.
14. Pal, A., S. Behera, and K. J. Vinoy. Design of multi-frequency microstrip antennas using multiple rings, *IET Microwaves Antennas and Propagation*, Vol. 3, 77–84 (2009)
15. Krishna, D. D., M. Gopikrishna, C. K. Aanandan, Mohanan P., and Vasudevan K. Compact dual band slot loaded circular microstrip antenna with a superstrate, *Progress In Electromagnetics Research*, PIER 83, pp. 245–255 (2008).
16. Al-Zoubi, F. Yang and A. Kishk, "A Broadband Center-Fed Circular Patch-Ring Antenna With a Monopole Like Radiation Pattern," in *IEEE Transactions on Antennas and Propagation*, vol. 57, no. 3, pp. 789-792, March 2009.doi: 10.1109/TAP.2008.2011406.
17. M. John and M. J. Ammann, "Wideband Printed Monopole Design Using a Genetic Algorithm," in *IEEE Antennas and Wireless Propagation Letters*, vol. 6, pp. 447-449, 2007.doi: 10.1109/LAWP.2007.891962.
18. J. Row and S. Wu, "Circularly-Polarized Wide Slot Antenna Loaded With a Parasitic Patch," in *IEEE Transactions on Antennas and Propagation*, vol. 56, no. 9, pp. 2826-2832, Sept. 2008.doi: 10.1109/TAP.2008.928769.

Global Journal of Researches in Engineering (F) Volume XIX Issue IV Version I Year 2019

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 19 Issue 4 Version 1.0 Year 2019
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Model on Optimizing Primary Spectrum Allocation using Cognitive Radio

By Omorogiuwa, O. S. & Nwukor, F. N

University of Benin

Abstract- This paper presents Model on optimizing primary spectrum allocation using cognitive radio. A theoretic dynamic spectrum access algorithm that improves upon on a hedonic coalition formation algorithm for spectrum sensing and access for frequency modulation radio spectrum is presented. The modified algorithm is tailored to eliminate interference, faster convergence and makes use of a simultaneous multi-channel sensing and access technique. Results to demonstrate the performance improvements of the adapted algorithm are presented and the use of different decision rules are investigated revealing that primary spectrum can be used without interference with the secondary user. The algorithm that was developed could be a key for prospect primary spectrum networks to be used.

Keywords: cognitive radio (CR), spectrum, secondary users (SUS), primary users (PUS).

GJRE-F Classification: *FOR Code: 290901*

MODELONOPTIMIZINGPRIMARYSPECTRUMALLOCATIONUSINGCOGNITIVERADIO

Strictly as per the compliance and regulations of:

OPEN ASSOCIATION OF RESEARCH SOCIETY, USA
RESEARCH | DIVERSITY | ETHICS

Model on Optimizing Primary Spectrum Allocation using Cognitive Radio

Omorogiuwa, O. S. [α] & Nwukor, F. N [σ]

Abstract- This paper presents Model on optimizing primary spectrum allocation using cognitive radio. A theoretic dynamic spectrum access algorithm that improves upon on a hedonic coalition formation algorithm for spectrum sensing and access for frequency modulation radio spectrum is presented. The modified algorithm is tailored to eliminate interference, faster convergence and makes use of a simultaneous multi-channel sensing and access technique. Results to demonstrate the performance improvements of the adapted algorithm are presented and the use of different decision rules are investigated revealing that primary spectrum can be used without interference with the secondary user. The algorithm that was developed could be a key for prospect primary spectrum networks to be used.

Keywords: cognitive radio (CR), spectrum, secondary users (SUS), primary users (PUS).

I. Introduction

The Smart Devices (SD), which are also referred to as Internet of Things (IoT) are increasing every day and are gaining focus because most organisations and individuals are using the device. Internet of Things refers to billions of physical machines around the globe that are linked to the internet, assembling and sharing data (Nidhi and Rajeev, 2019). Any physical entity can be transformed into an Internet of things machines if it can be linked to the Internet/Ethernet and controlled (Hsu *et al,* 2016).

As of 2016, the prediction of the Internet of things has advanced due to a convergence of numerous technologies, as well as wireless communication, real-time analytics, machine learning, product sensors, and embedded systems. The acceptance of Radio Frequency Identification (RFID) tags (low power chips that can communicate wirelessly) resolved some of this concern. The accessibility of broadband internet, cellular and wireless networking also helps in facilitating the growth of Internet of Things (Hus *et al*, 2016). Internet of Things also finds application in checking electric grid, telecommunication at real time, and help to encourage healthy living by use of consumer machines such as linked scales or wearable heart check (Hus *et al,* 2016; Kang *et al*, 2017).

Author α: Department of Electrical and Electronics Engineering. University of Benin, Benin City, Nigeria. e-mail: sam@uniben.edu
Author σ: Petroleum Training Institute, Effurun, Delta State, Nigeria. e-mail: francesnkem@gmail.com

With the advancement in communication technology, the IoT machines have introduced a new class of low-power short-range wireless machines that uses radio spectrum for the switching of information (Asghar *et al*, 2015). The requirement for these machines are creating irresistible demand on the radio spectrum (secondary licensing) (Asghar *et al,* 2015); thereby causing shortage of frequency. Other wireless machines that use secondary spectrum have been facing interference (Otermat *et al,* 2015; Singh *et al,* 2014), since some range of spectrum are free (secondary spectrum), any user can use any spectrum that he/she assume is good for his/her machine not considering other users (Stankovic, 2014).

The number of Internet of Things machines is predicted to reach 200 billion by the year 2020 (Asghar *et al,* 2015; Stankovic, 2014). This rapid growth of internet of things machines are introducing high demand for the switching of information. Hence with the new discovery, it also brings the crisis; communication field frequency insufficiency which is at the present becoming extremely a main crisis as man discovers appliances every day.

To compensate this extraneous demand for radio spectrum, each application have need for spectrum to function, but with limited amount of frequency obtainable for proper throughput communication (secondary spectrum) (Asghar *et al,* 2015). As a result of this, Primary spectrum need to be analysed in order to locate any vacant spectrum that IoT machines need to utilise, to solve the shortage of radio frequency and throughput.

Cognitive radio (CR) device have been proven using a novel method to identify free and used radio spectrum. If IoT machines will be able to regulate their machines parameters, such as transmit (broadcast) power and frequency, in order to optimize their throughput at the same time minimizing intrusion to the primary spectrum license user, with the help of cognitive radio. We can predict the spectrum hole and use the free spectrum (Otermat *et al*, 2016).

This study will have a significant impact on spectrum allocation to secondary user, method that will use the underutilised spectrum in the primary spectrum through a novel use of CR.

To communicate between IoT devices over a 2.4/5GHz radio frequency it becomes problematic when other nearby devices are using that frequency (Dawid, 2017). Tan and Wang, (2010) proposed a variant of the Open Systems Interconnection (OSI) model for the IoT architecture. The first layer is splitted between Existed Alone Application System Layer and Edge Technology Layer/Access Layer. The second, third, fourth, and fifth layers are Backbone Network Layer, Coordination Layer, Middleware Layer, and Application Layer, respectively. Each of these different layers possesses its own enabling technology.

According to Experts, 30 billion connected devices will exist by 2020, these many devices competing for wireless spectrum will cause severe congestion (Zhang *et al,* 2012). Alleviating spectrum congestion is the primary reason for incorporating CR in IoT.

One of the most revolutionary applications of CR is addressing spectrum scarcity in wireless communications. The spectrum is scarce primarily because of the way it is licensed. CR provides the technical framework for spectrum sharing of the underutilised spectrum (Hassanieh *et al*, 2014; Haykin, 2015), the underutilised spectrum for use by CIoT devices will be key to the future success of ever increasing IoT networks.

Review of the spectrum scarcity research was conducted to prove that spectrum scarcity is indeed a pseudo situation (Omorogiuwa and omozusi, 2018). It is pseudo in the sense that the spectrum remains idle or vacant majority of the time. However, it cannot be utilised by anyone but the primary license holder.

This study focused on developing FM frequency allocation to secondary user without interference.

II. Method

a) Algorithm Model

i. System Architecture

There are two types of network architectures in the FM spectrum system: the allocated spectrum and the unallocated spectrum, as we know, the entire spectrum is made up of a number of channels. There are FM spectrum channel in total which can be represented as M and there are allocated FM which can be represented as K and there are unallocated FM spectrum which can be represented as L; with set PUs K∊{1,...,K} and SUs as L∊{1,...,L}. the PU operational in different channel can either be 1 or 0 which denote PUi i∊ K and the bitrates of such a channel can be represented as Bi which for kwon is not relevant in this model, Figure 1 represent M spectrum =K + L, which can be denoted as M = 100 Channel, if K = 12, that means L (unallocated) = 100 – 12 = 88 channel.

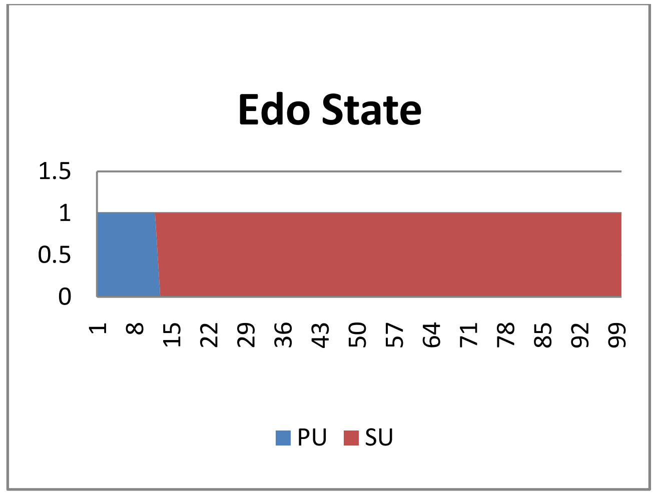


Figure 1: Denote the total number of FM stations

b) Channel Occupancy Model

A model is used to represent the status of each channel as discussed in System Architecture, in which there is intermittent channel switching between unallocated idle and unallocated busy, to avoid interference with the PUs allocated and to track the spectrum before transmission, The SUs perform spectrum sensing, this is necessary because the SUs are using the free spectrum of PUs and that means each SUs can be represented by SUj j∊ L. for a SU can access one frequency of the M channels where it is 0. If PUi is 1 in the spectrum of interest i, i∊ K is denote by H1i; if PUi is absent, this dente by H0i, but this assumption will not be since, if the FM station allocated are made constant, that means the model will improve to SUi; which means when SU is busy, it will denote H1i and when is idle, it will be SU0i. This assumption was made that every user is entitled to only one transceiver operating in half duplex; it is required of the SU to have spectrum nimbleness with embedded dynamic frequency selection. The likelihood of the SUi being active is connoted as SU1i; the likelihood of it being inactive is connoted as SU0i; that shows SUH1i + SUH0i = 1, Figure 2 shows the chain representation of the model.

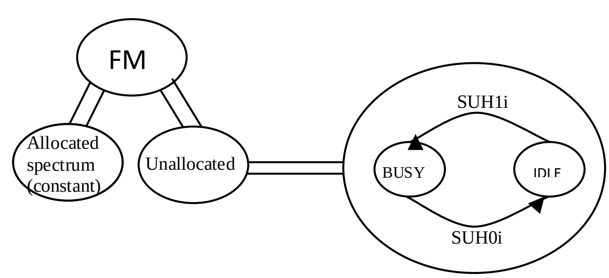


Figure 2: Show the chain representation of the develop

From Figure 2 there are some probability discretions in regarding the resolution of active (busy) and inactive (idle).

First system probability discretion, that channel i is idle and PUi is constant, true negative, which means the probability P0/0i = PH0i(1 – Pf,i)

Second system determination that the channel SUi is occupied and PUi remains constant that is a false positive occurring with a probability P1/0i = PH1i,Pfi.

Third system determination that channel PUi is dormant while SUi is functional, that is false negative occurring with aa probability P0/1i = PH1i(1 – Pfi)

Fourth system determination that channel PUi is active as SUi (means all unallocated FM station) is active that means a true positive occurring with a probability P1/1i = PH1i,Pfi

As indicated, the algorithm presented in Channel Occupancy Model shows notable improvements in the alliance formation algorithm which forms the basis of the alliance. The model convergence time is quicker in decision making. This comes as a result of putting PU as constant, while multiple SUs are allowed to sense channel more than one time. Both the processes of channel sensing and access can be performed by Multiple SUs at a time, while the same channels in the PU (constant) spectrum are not sensed or accessed. The outcome thus is that there is no discord or interference of PU in the network.

Code

This code was used to display the graph using the simulation.

```
SP:
val_F=Data
IF Data<100 then
R_val=100 – Data
Else
R_val = 100
Goto sp:
End
```

III. Performance

a) Simulation parameters

The FM frequency spectrum range contains the network nodes distributed in it. The algorithm was use to compared PU and SU for access and dynamic spectrum sensing. The average utility of SUs in the spectrum used for comparison was the main matrix and this average utility of SUs depends on the constant (PU) value in each State. Simulation parameters of different state as shown in Table 2 this was use to vary and decide the resulting outcome on average spectrum SU utility. Table 1 shows the parameters of the default simulation that was used and the results is shown in Figures 3 to 9.

Table 1: Simulation Parameters

Parameter	Description	Value
M	Number of channels	100
K	Number of primary users	Depends on the state
L	Number of secondary users	Depends on the state
PH1,i	Probability of PU active	Constant
PH1,i	Probability of SU active	Varies
PH0,i	Probability of SU inactive	Varies

Table 2: FM radio stations and their percentage utilisation

S/N	State	FM Stations	$S_{Unallocated}$ MHz	Percentage Underutilisation
1	Abia	10	18	90
2	Adamawa	6	18.8	94
3	Akwa Ibom	8	18.4	92
4	Anambra	19	16.2	81
5	Bauchi	4	19.2	96
6	Bayelsa	6	18.8	94

Global Journal of Researches in Engineering (F) Volume XIX Issue IV Version I Year 2019

7	Benue	7	18.6	93
8	Borno	6	18.8	94
9	Cross River	7	18.6	93
10	Delta	14	17.2	86
11	Ebonyi	2	19.6	98
12	Edo	10	18	90
13	Ekiti	4	19.2	96
14	Enugu	13	17.4	87
15	Gombe	6	18.8	94
16	Imo	11	17.8	89
17	Jigawa	8	18.4	92
18	Kaduna	19	16.2	81
19	Kano	21	15.8	79
20	Katsina	4	19.2	96
21	Kebbi	3	19.4	97
22	Kogi	5	19	95
23	Kwara	9	18.2	91
24	Lagos	36	12.8	64
25	Nasarawa	8	18.4	92
26	Niger	7	18.6	93
27	Ogun	17	16.6	83
28	Ondo	15	17	85
29	Osun	10	18	90
30	Oyo	29	14.2	71
31	Plateau	11	17.8	89
32	Rivers	18	16.4	82
33	Sokoto	6	18.8	94
34	Taraba	4	19.2	96
35	Yobe	1	19.8	99
36	Zamfara	1	19.8	99
37	FCT	29	14.2	71

Source: Omorogiuwa and Nwukor

Each state in the Country has an average of 5-12 FM radio stations. Since there are 100 possible radio channels that could be occupied at any given location (latitude and longitude coordinate), that show the FM radio channels in Nigeria is 89% underutilised.

b) Alliance formation

The number of channels available determines the number of alliance available to join each channel. To aid visualization of the alliances, charts were drawn to show the total FM spectrum. SUs and PUs in the network were generated with the assumption as discussed in Algorithm Model and Channel Occupancy Model and the colour of the node as shown in Figures 3 to 9

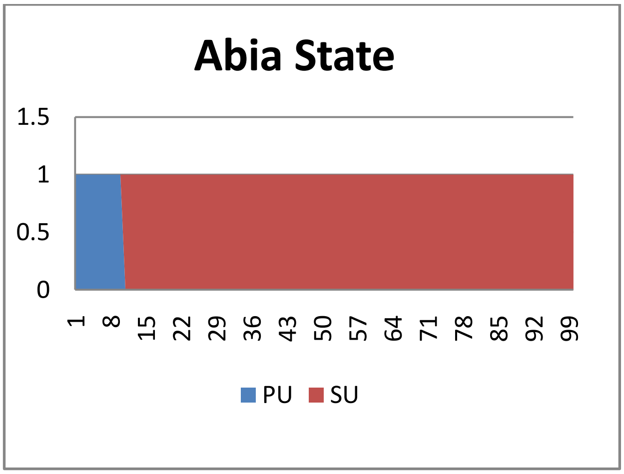


Figure 3: Network repersentation of Abia State total FM spectrum, PU and SU repersentation

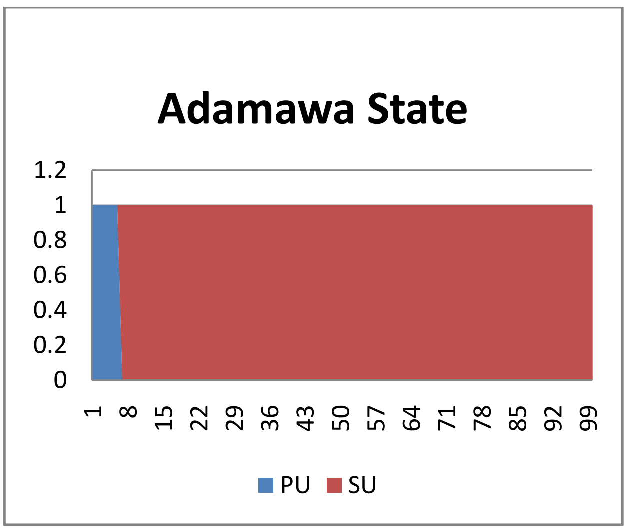


Figure 4: Network repersentation of Adamawa State total FM spectrum, PU and SU repersentation

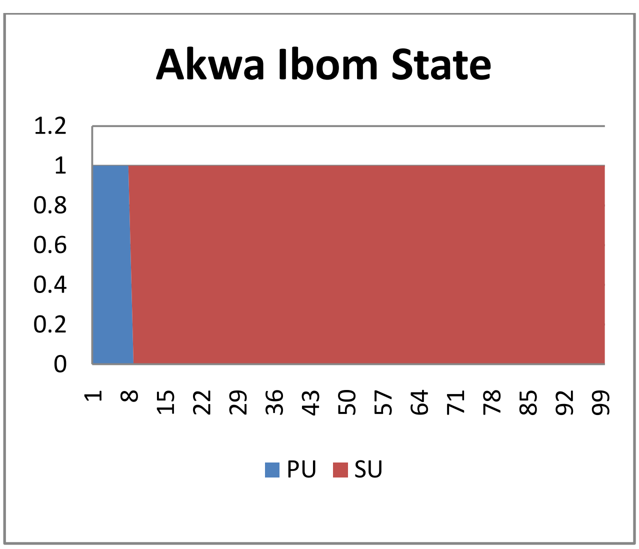


Figure 5: Network reperse ntation of Akwa Ibom State total FM spectrum, PU and SU repersentation

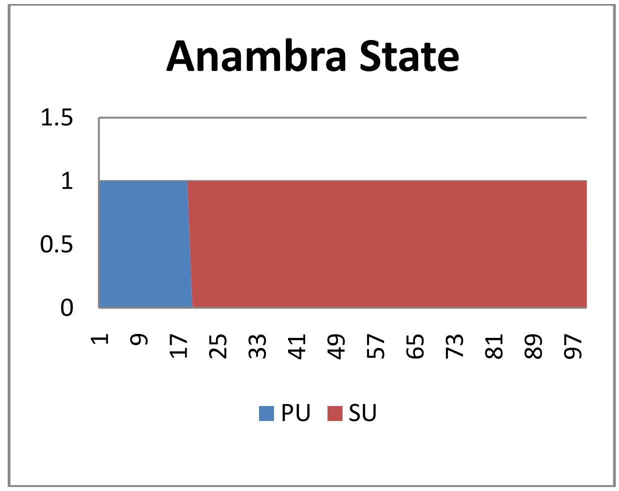


Figure 6: Network repersentation of Anambra State total FM spectrum, PU and SU repersentation

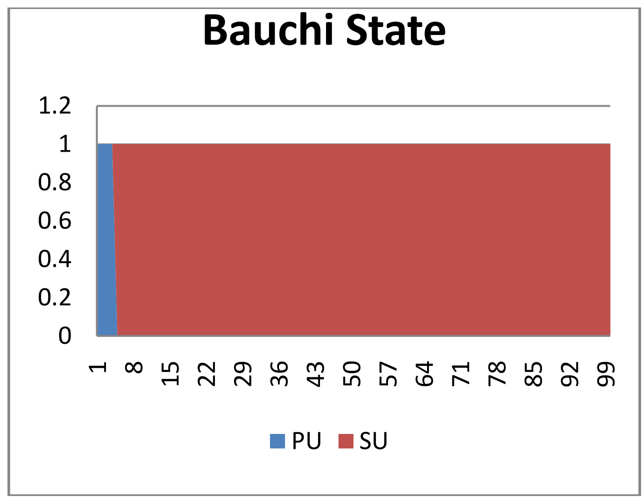


Figure 6: Network repersentation of Bauchi State total FM spectrum, PU and SU repersentation

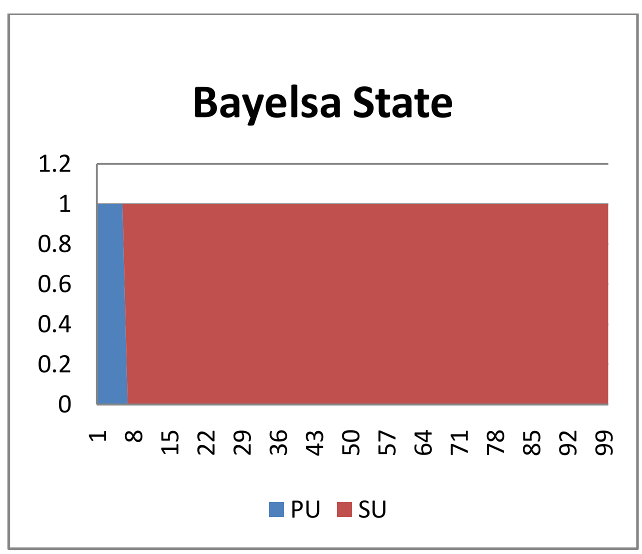


Figure 8: Network repersentation of Bayelsa State total FM spectrum, PU and SU repersentation

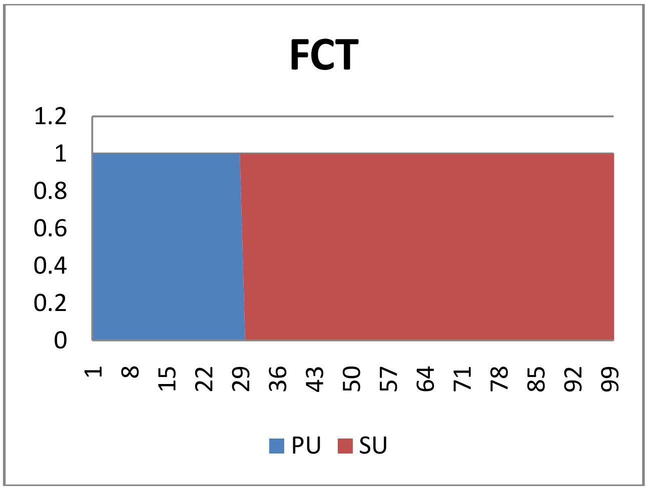


Figure 9: Network repersentation of Federal capital territory Nigeria total FM spectrum, PU and SU repersentation.

From the chart that was shown in Figure 3-9, First system decision that channel i is idle and PUi is constant, true negative, which means the probability P0/0i = PH0i(1 – Pf,i) as described in Channel Occupancy Model was use to formulated the results in Figures 3 – 9. It was an indicator that there is free spectrum in the FM station. This indicates how many SUs and PUs are in each alliance. The organisations of PUs and SUs across the alliances are what the spectrum sensing and access algorithm seeks to optimize, in reflecting the average utility of the spectrum.

Second system determination that the channel SUi is occupied and PUi remains constant that is a false positive occurring with a probability P1/0i = PH1i,Pfi, using Abia, Adamawa, Delta State. The assumptions are represented in Figures 10 to 12.

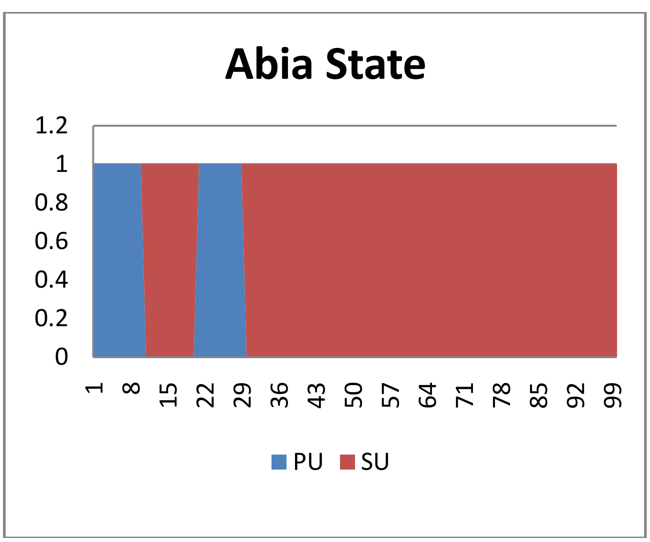


Figure 10: Network repersentation of Abia State total FM spectrum, PU and SU repersentation

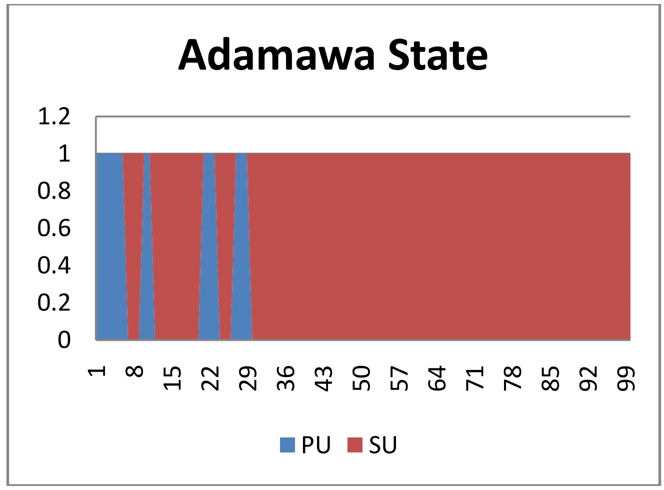


Figure 11: Network repersentation of Adamawa State total FM spectrum, PU and SU repersentation

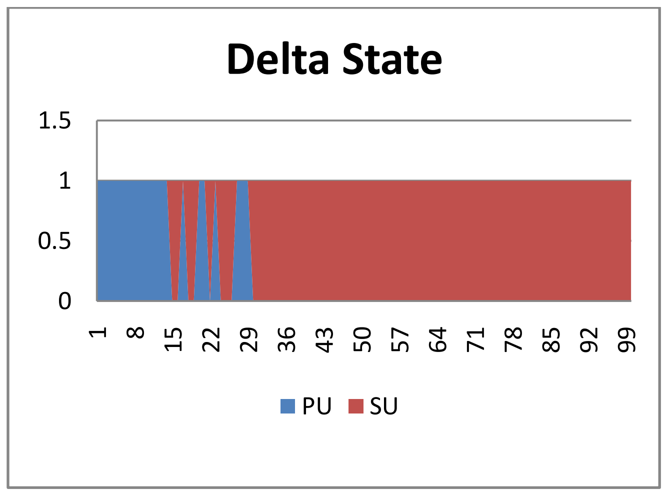


Figure 12: Network repersentation of Delta State total FM spectrum, PU and SU repersentation

From the chart in Figures 10 – 12, it was shown that if any spectrums from the secondary user are allocated it becomes constant that means the spectrum cannot be reallocated to any user.

IV. Conclusion

In this paper, better approaches of spectrum sharing were obtained and analysis was done. Algorithm model with channel occupancy model for multi-channel dynamic access was presented. The details of a collaborative spectrum sharing technique were presented from an analytical perspective and an adapted algorithm for fast convergence in a hedonic coalition technique was soon. From the technique shown, if compared with other model, that put the primary license holder as parity 1 and secondary user as parity 2, the system will use time to scan if parity 1 is available or when using the spectrum, when parity 1 is active (primary user), the secondary user will disconnect, which will lead to loss of packet. But the performance of the model can operate in the primary user spectrum and secondary user spectrum without causing interference to the primary spectrum. It will be better if NCC approve this model because if implemented, it will protect the primary license holder and will also protect the secondary user.

References Références Referencias

1. Asghar M. H., A. Negi and N. Mohammadzadeh, (2015) "Principle Application and Vision in Internet of Things (IoT), *International Conference on Computing, Communication and Automation (ICCCA2015), Uttar Pradesh*.
2. Dawid Sibiński (2017) WiFi and Bluetooth interference – diagnosing and fixing publisher *Dawid's blog*.
3. Hassanieh H., L. Shi, O. Abari, E. Hamed, and D. Katabi Ghz-wide (2014), Sensing and decoding using the sparse fourier transform. *In INFOCOM, 2014 Proceedings IEEE*, 2256–2264.
4. Haykin S., (2005) "Cognitive Radio: Brain-Empowered Wireless Communications," *IEEE Journal on Selected Areas in Communications*, 20 (2) 201-220.
5. Hsu, Chin-Lung; Lin, Judy Chuan-Chuan, (2016) "An empirical examination of consumer adoption of Internet of Things services: Network externalities and concern for information privacy perspectives" . *Computers in Human Behavior*. (62): 516– 527. doi:10.1016/j.chb.2016.04.023.
6. Kang, Won Min; Moon, Seo Yeon; Park, Jong Hyuk (2017). An enhanced security framework for home appliances in smart home. *Human-centric Computing and Information Sciences*. 7 (6). doi:10.1186/s13673-017-0087-4.
7. Omorogiuwa, O. S and Omozusi E. J., (2018) Monitoring of Spectrum Usage and Signal Identification Using Cognitive Radio, *ICTCS Telecommunication and Communication Science*.
8. Omorogiuwa O. S and Nwukor, F. N. 2019, Analysis of Radio Frequency (87.5 – 108 MHz) For Short Range Low Power Smart Device Utilization, ATBU, Journal of Science, Technology & Education (JOSTE). Pp 45-45.
9. Otermat D. T., I. Kostanic and C. E. Otero (2016), Analysis of the FM Radio Spectrum for Secondary Licensing of Low-Power Short-Range Cognitive Internet of Things Devices, *IEEE Access,* 99: 11-19.
10. Otermat Derek T., Carlos E. Otero, Ivica Kostanic. (2015) "Analysis of the FM radio spectrum for Internet of Things opportunistic access via Cognitive Radio",*IEEE 2nd Globe Forum on Internet of Things (WF-IoT)*.
11. Singh D., G. Tripathi and A. J. Jara, (2014), "A survey of Internet-of-Things: Future Vision, Architecture, Challenges and Services," *in IEEE Globe Forum on Internet of Things (WF-IoT), Seoul.*
12. Stankovic J. A., (2014), "Research Directions for the Internet of Things," *IEEE Internet of Things Journal, vol. 1(1), 3-9.*
13. Tan L. and N. Wang, (2010) "Future Internet: The Internet of Things," *Advanced Computer Theory and Engineering (ICACTE), Chengdu*.
14. Zhang Y., R. Yu, M. Nekovee, L. Y and S. G. S. Xie, (2012) "Cognitive Machine-to Machine Communications: Visions and Potentials for the Smart Grid," *IEEE Network Journal*, pp. 6-13.
15. Nidhi Sharma and Rajeev mohan Sharma 2019, 5G IGI Global.

This page is intentionally left blank

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 19 Issue 4 Version 1.0 Year 2019
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

TCAD Based Simulation and Performance Optimization of InxGa(1-X)N based Solar Cell

By Deepak Kumar Mangal, A. D. D. Dwivedi, Md. Asif Iqbal & Surender Kumar Sharma

Poornima University Jaipur

Abstract- Solar cells are a promising renewable and carbon-free electric energy resource to address the fossil-fuel shortage and global warming. Various studies on solar cells using III-nitrides semiconductors in the photovoltaic applications have been done. Among them the InGaN alloy is a promising candidate for the photovoltaic applications because it exhibits attractive photovoltaic properties such as high tolerance to radiation, high mobility, and large absorption coefficient allowing thinner layers of material to absorb most of the solar spectrum.

Indium Gallium Nitride (InGaN) solar cells might yield high bene fits concerning efficiency and reliability, because its bandgap can be tuned through the Indium composition(from 0.7 eV to 3.42 eV) and It's energy range covering approximately the total solar spectrum[1].

Keywords: indium gallium nitrite (InGaN), energy band gap (EG), efficiency, fill factor (FF), open-circuit voltage, short-circuit current density, iii-nitride.

GJRE-F Classification: FOR Code: 090699

TCADBASEDSIMULATIONANDPERFORMANCEOPTIMIZATIONOFINXGA1XNBASEDSOLARCELL

Strictly as per the compliance and regulations of:

Open Association of Research Society, USA
Research | Diversity | Ethics

TCAD Based Simulation and Performance Optimization of $In_xGa_{(1-X)}N$ based Solar Cell

Deepak Kumar Mangal [α], A. D. D. Dwivedi [σ], Md. Asif Iqbal [ρ] & Surender Kumar Sharma [ω]

Abstract- Solar cells are a promising renewable and carbon-free electric energy resource to address the fossil-fuel shortage and global warming. Various studies on solar cells using III-nitrides semiconductors in the photovoltaic applications have been done. Among them the InGaN alloy is a promising candidate for the photovoltaic applications because it exhibits attractive photovoltaic properties such as high tolerance to radiation, high mobility, and large absorption coefficient allowing thinner layers of material to absorb most of the solar spectrum.

Indium Gallium Nitride (InGaN) solar cells might yield high benefits concerning efficiency and reliability, because its bandgap can be tuned through the Indium composition(from 0.7 eV to 3.42 eV) and It's energy range covering approximately the total solar spectrum[1]. In this paper we report the TCAD simulation and performance optimization of $In_xGa_{(1-x)}N$ based solar cell. Evaluation of the performance of the device has been performed for various values of mole fraction x of In in In GaN. Dark and illuminated I-V characteristics of the device has been simulated and performance parameters of the device have been extracted. The extracted optimized performance parameters of the device are: open circuit voltage (V_{oc}) of 1.08 V, Short circuit current (I_{sc}) is 0.027A, Fill Factor (FF) is 88.58%, Maximum voltage (V_{max}) is 0.99 V, Maximum current (I_{max}) is 0.26A and overall efficiency is 19.36%

Keywords: indium gallium nitrite (InGaN), energy band gap (EG), efficiency, fill factor (FF), open-circuit voltage, short-circuit current density, iii-nitride.

I. Introduction

Group III-V nitride are now a widely studied class of semiconductor materials. $In_xGa_{(1-x)}N$, with small x, are very eficient light emitters, even in samples with relatively high densities of structural defects are used as component layers in a wide range of optoelectronic devices. Its high light absorption and its Indium–composition–tuned band gap, the Indium Gallium Nitride (InGaN) ternary alloy is a good candidate for high–efficiency–high–reliability solar cells able to operate in harsh environments.

Moreover, the most important advantage of InGaN alloy might be the direct band gap energy which can be adjusted according to the indium composition. Thus, the InGaN's energy band gap can be tuned from 0.7 eV to 3.42 eV, covering approximately the total solar spectrum[1]. In this paper, we present simulation of InGaN based p-n homo junction solar cell at different Indium composition . The layers of InGaN solar cell can be deposited using the cost-effective techniques, such as Metal Organic Chemical Vapor Deposition (MOCVD), Metal Organic Vapor Phase Epitaxy (MOVPE), and Molecular Beam Epitaxy (MBE) [2]. Whatever the deposition technique used, higher growth rates (~1.0 Angstrom/second) and lower temperature(~550 °C) characterize the InGaN growth [3]

II. Modelling and Simulation

a) Structure

As the numerical simulation is an important way to explore the possibility of a new solar cell structure the InGaN single p-n junction solar cell has been studied using commercial device simulator Atlas from Dilvaco Inc [4].

All the simulations were performed under normalized conditions that are 1 sun, a temperature of 300 K, and AM0 illumination. The $In_xGa_{(1-x)}N$ single p-n junction solar cell structure studied consists of p-type emitter and n-type base as shown in Fig. 1.

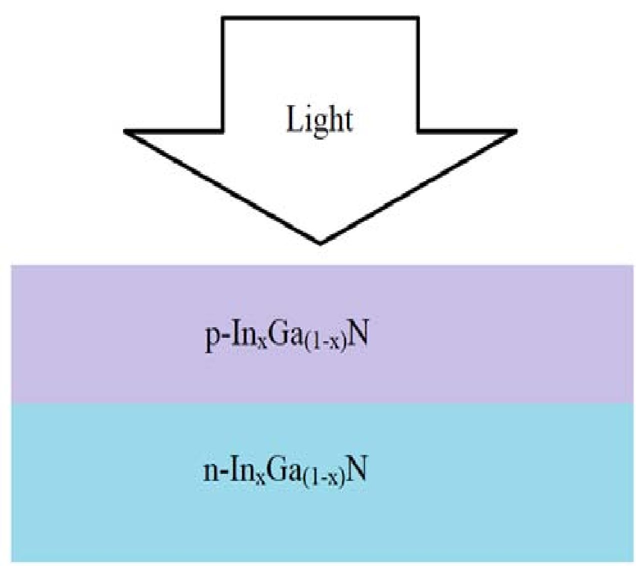


Fig. 1: $In_xGa_{(1-x)}N$ single p-n junction solar cell structure

*Author α σ ρ ω : Department of Electrical and Electronics Engineering, poornima University Jaipur, Rajasthan, India- 303905.
e-mail: adddwivedi@gmail.com*

Table 1: Energy Band Gap of $In_xGa_{(1-x)}N$ at x

Material $In_xGa_{(1-x)}N$	Energy band gap (Eg)
GaN	3.42
$In_{0.20}Ga_{0.80}N$	2.6612
$In_{0.35}Ga_{0.65}N$	2.1672
$In_{0.50}Ga_{0.50}N$	1.7375
$In_{0.62}Ga_{0.38}N$	1.4401
$In_{0.78}Ga_{0.22}N$	1.1076
$In_{0.90}Ga_{0.10}N$	0.9063
InN	0.77

b) Physical & Optical Perameters

The energy band gap of $In_xGa_{(1-x)}N$ is depended on concentration of Indium (x) and energy band gap of $In_xGa_{(1-x)}N$ is given by following formula

$$E_g\left(In_xGa_{(1-x)}N\right)=x.E_g^{InN}+(1-x).E_g^{GaN}-b.x.(1-x) \quad (1)$$

where the band gap energy of InN denoted as E_g^{InN} and band gap energy of GaN denoted as E_g^{GaN} is 0.7eV and 3.42eV, respectively, x is the indium content and b is the bowing parameter (b = 1.43) [5-6].

The other modeling parameters of the $In_xGa_{(1-x)}N$ alloy were calculated using the following equations-

Electron Affinity[7-9]: -

$$\chi\left(In_xGa_{(1-x)}N\right)=4.1+0.7(3.4-E_g) \quad (2)$$

Relative permittivity[6]: -

$$\varepsilon\left(In_xGa_{(1-x)}N\right)=15.3x+8.9(1-x) \quad (3)$$

Table 2: Value of electron affinity and relative permittivity of $In_xGa_{(1-x)}N$ at different value of x

Material $In_xGa_{(1-x)}N$	Electron Affinity(X)	Relative permittivity(E)
GaN	4.092	8.9
$In_{0.20}Ga_{0.80}N$	4.3955	10.18
$In_{0.35}Ga_{0.65}N$	4.5931	11.14
$In_{0.50}Ga_{0.50}N$	4.765	12.1
$In_{0.62}Ga_{0.38}N$	4.884	12.868
$In_{0.78}Ga_{0.22}N$	5.017	13.892
$In_{0.90}Ga_{0.10}N$	5.0975	14.66
InN	5.152	15.3

Effective density of conduction band[8-9]: -

$$N_C\left(In_xGa_{(1-x)}N\right)=(0.9x+2.3(1-x)).10^{18} \quad (4)$$

Effective density of valence band[8-9]: -

$$N_V\left(In_xGa_{(1-x)}N\right)=(5.3x+1.8(1-x)).10^{19} \quad (5)$$

Table 3: Value of Effective density of conduction Band and valance band in $In_xGa_{(1-x)}N$ at different value of x

Material $In_xGa_{(1-x)}N$	Effective density of Conduction band (Nc) (1×10^{18})	Effective density of Valance Band(Nv) (1×10^{20})
GaN	0	0
$In_{0.20}Ga_{0.80}N$	1.8	1.06
$In_{0.35}Ga_{0.65}N$	3.15	1.855
$In_{0.50}Ga_{0.50}N$	4.5	2.65
$In_{0.62}Ga_{0.38}N$	5.58	3.286
$In_{0.78}Ga_{0.22}N$	7.02	4.134
$In_{0.90}Ga_{0.10}N$	8.1	4.77
InN	9	5.3

Effective mass of electron[7]

$$m_n\left(In_xGa_{(1-x)}N\right)=0.12x+0.2(1-x) \quad (6)$$

Effective mass of hole

$$m_h\left(In_xGa_{(1-x)}N\right)=0.17x+1.0(1-x) \qquad (7)$$

Table 4: Value of effective masses of electron and hole in $In_xGa_{(1-x)}N$ at different value of x

Material $In_xGa_{(1-x)}N$	Effective Mass of Electron (Mn)	Effective Mass of Hole (Mh)
GaN	0.2	1
$In_{0.20}Ga_{0.80}N$	0.184	0.834
$In_{0.35}Ga_{0.65}N$	0.172	0.7095
$In_{0.50}Ga_{0.50}N$	0.16	0.585
$In_{0.62}Ga_{0.38}N$	0.1504	0.4854
$In_{0.78}Ga_{0.22}N$	0.1376	0.3526
$In_{0.90}Ga_{0.10}N$	0.128	0.253
InN	0.12	0.17

Intrinsic carrier concentration: -

$$n_i^2=N_CN_Ve^{-E_g/K_BT} \qquad (8)$$

Where K_B is Boltzmann constant and T is lattice temperature

Efficiency: -

$$\eta(\%)=\frac{I_{SC}.V_{OC}.FF}{P_{in}} \qquad (9)$$

Where I_{SC} is short circuit current, V_{OC} is open circuit voltage, P_{in} is incident optical power and FF is fill factor of the solar cell.[10]

Table 5: Value of mobility of electron and hole $In_xGa_{(1-x)}N$ at different value of x

Material $In_xGa_{(1-x)}N$	Mobility of Electron (MUN or Un)	Mobility of Hole (MUP or Uh)
GaN	1000	170
$In_{0.20}Ga_{0.80}N$	1104.8	171.3
$In_{0.35}Ga_{0.65}N$	1183.4	172.275
$In_{0.50}Ga_{0.50}N$	1262	173.25
$In_{0.62}Ga_{0.38}N$	1324.9	174.03
$In_{0.78}Ga_{0.22}N$	1408.7	175.07
$In_{0.90}Ga_{0.10}N$	1471.6	175.85
InN	1524	176.5

Mobility[11]: -

$$U_0(N,T)=U_{\min,i}\left(\frac{T}{300}\right)^{B1}+\frac{(U_{\max,i}-U_{\min,i})(T/300)^{B2}}{1+(N/Nref(T/300)^{B3})^{\gamma(T/300)^{B4}}} \quad \ldots\ldots(10)$$

The following equation (11,12) is simplified equation for electron & hole mobility for InGaN alloy.

$$U_n\left(In_xGa_{(1-x)}N\right)=(524*x)+U_{n(GaN)} \qquad (11)$$

$$U_h\left(In_xGa_{(1-x)}N\right)=(6.5*x)+U_{h(GaN)} \qquad (12)$$

Where the $U_{n(GaN)}$ is 1000 & $U_{h(GaN)}$ is 170.

For the $In_xGa_{1-x}N$ alloys, Adachi's wavelength-dependent refractive index model is given by the following equation [6, 12]:

$$n(E)=\sqrt{A\left(\frac{E_{ph}}{E_g}\right)^{-2}\left\{2-\sqrt{1+\frac{E_{ph}}{E_g}}-\sqrt{1-\frac{E_{ph}}{E_g}}\right\}+B} \quad \ldots\ldots.(13)$$

Where Eph is photon Energy A & B is coefficient dependent on material composition that equation giving by following equation.

$$A\left(In_xGa_{(1-x)}N\right)=13.55x+9.31(1-x) \quad \ldots\ldots..(14)$$

$$B\left(In_xGa_{(1-x)}N\right)=02.05x+3.03(1-x) \quad \ldots\ldots.(15)$$

This real part of refractive index is approximate same 2.32

Its slightly worry for InGaN alloy with different composition of x from 2.30 to 2.34.

The InGaN alloys absorption coefficient α is given by equation (16)[13]

$$\alpha\left(In_xGa_{(1-x)}N\right)=10^5\sqrt{C(E_{ph}-E_g)+D(E_{ph}-E_g)^2} \quad \ldots\ldots(16)$$

Where C & D are fitting parameter that is given by following equation (17,18)

$$C\left(In_xGa_{(1-x)}N\right) = 3.525 - 18.29x + 40.22x^2 - 37.52x^3 + 12.77x^4 \quad \ldots(17)$$

$$D\left(In_xGa_{(1-x)}N\right) = -0.665 + 3.616x - 2.460x^2 \ldots(18)$$

Following equation is simplified expression of absorption coefficient α (19)

$$\alpha\left(In_xGa_{(1-x)}N\right) = 2.2 * 10^5 \sqrt{\frac{1.24}{\lambda} - E_g} \ldots\ldots\ldots\ldots(19)$$

Where λ is photon wavelength

For the $In_xGa_{1-x}N$ alloys, wavelength- dependent imaginary part of refractive index is given by the following equation

$$K = \frac{\lambda\alpha}{4\Pi} \ldots\ldots\ldots\ldots(20)$$

Where pie (π) is 3.14.

Following Fig. 2 is graph of wavelength vs imaginary part of refractive index at different value of x

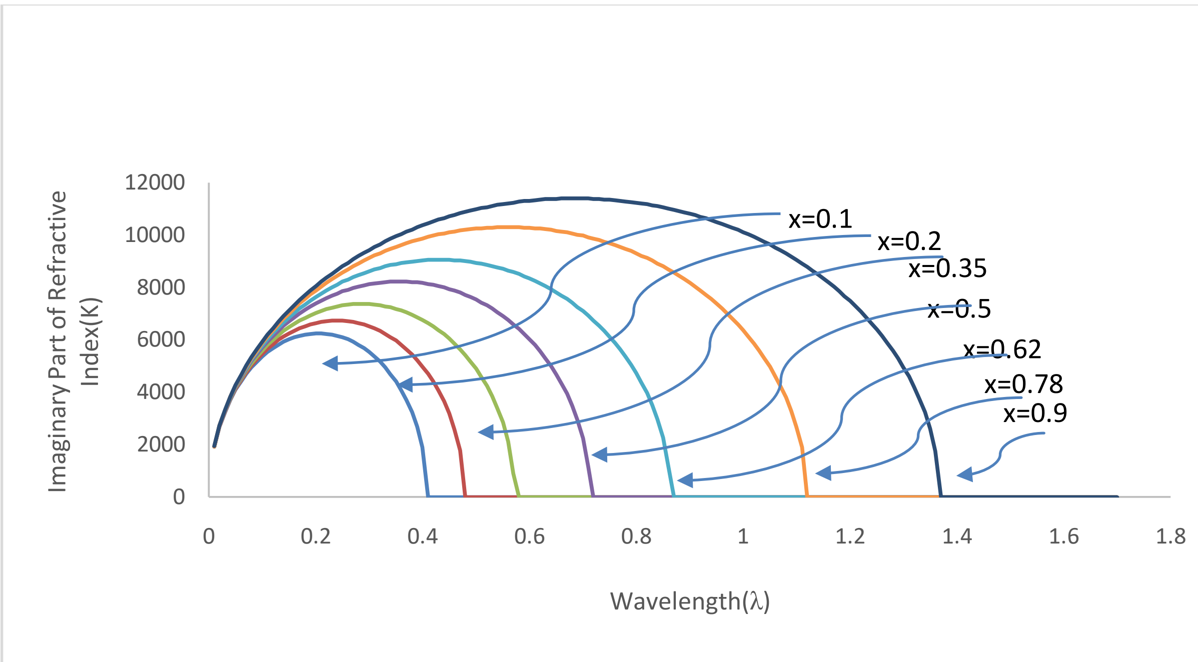


Fig. 2: Graph of wavelength vs imaginary part of refrective index at different value of x

Some initial parameter are given in the following table-6

Table 6: Initial optimized values for simulation

Parameter Used	Value
Thickness of n-InGaN layer	0.015 micron
Thickness of p-InGaN layer	0.63 micron
n-type doping [cm^{-3}]	2e18
p-type doing [cm^{-3}]	1×10^{17}
Velocity of electron & hole ($S_{n,h}$) [cm/s]	10^3
Recombination time of electron & hole ($\tau_{n,h}$)[sec.]	1ns

III. Result & Discussion

For the case studied, the initial physical and geometrical parameter values used for $In_xGa_{(1-x)}N$ single p-n junction solar cell are presented in table 6. After modeling & simulation get results with the help of above work following results are tabulates

Table 7: Simulation results of short circuit current and open circuit voltage $In_xGa_{(1-x)}N$ at different value of x

Material $In_xGa_{(1-x)}N$	Isc (mA/cm^2)	Voc (V)
$In_{0.20}Ga_{0.80}N$	0.00813315	1.9963
$In_{0.35}Ga_{0.65}N$	0.0158621	1.51555
$In_{0.50}Ga_{0.50}N$	0.0274789	1.08184
$In_{0.62}Ga_{0.38}N$	0.0385468	0.781803
$In_{0.78}Ga_{0.22}N$	0.0539032	0.446001
$In_{0.90}Ga_{0.10}N$	0.0654447	0.242227

This above table 7 presents simulation results of short circuit current & open circuit voltage at different composition of x for single p-n junction solar cell.

Table 8: Simulation results of maximum current and maximum voltage $In_xGa_{(1-x)}N$ at different value of x

Material $In_xGa_{(1-x)}N$	Im (mA/cm^2)	Vm (V)
$In_{0.20}Ga_{0.80}N$	0.00798644	1.88
$In_{0.35}Ga_{0.65}N$	0.01556	1.41
$In_{0.50}Ga_{0.50}N$	0.0265989	0.99
$In_{0.62}Ga_{0.38}N$	0.0372977	0.69
$In_{0.78}Ga_{0.22}N$	0.0507992	0.369998
$In_{0.90}Ga_{0.10}N$	0.0563837	0.19

This above table 8 presents simulation results of maximum current and maximum voltage at different composition of x for single p-n junction solar cell.

Table 9: Simulation results of fill factor and efficiency $In_xGa_{(1-x)}N$ at different value of x

Material $In_xGa_{(1-x)}N$	Fill Factor	Efficiency
$In_{0.20}Ga_{0.80}N$	92.4754	11.0401
$In_{0.35}Ga_{0.65}N$	91.2636	16.1321
$In_{0.50}Ga_{0.50}N$	88.5801	19.3624
$In_{0.62}Ga_{0.38}N$	85.3975	18.9231
$In_{0.78}Ga_{0.22}N$	78.1818	13.8203
$In_{0.90}Ga_{0.10}N$	67.5787	7.87713

This above table 9 shows simulation results of fill factor and efficiency at different composition of x for single p-n junction solar cell.

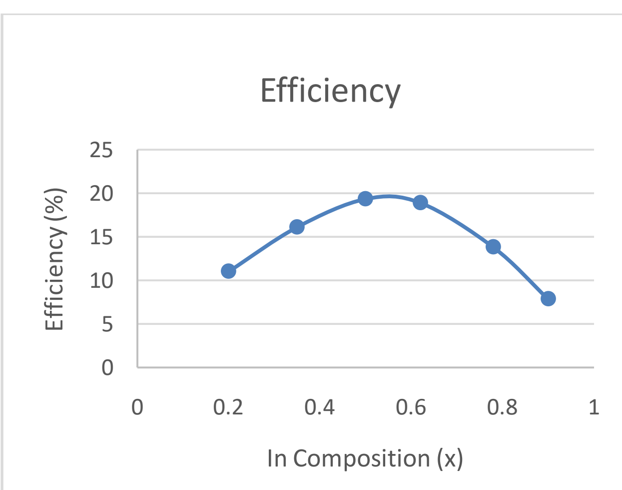


Fig. 3: Graph of In composition (x) efficiency at different value of x

After getting all results we gets maximum efficiency is 19.36% at $In_{0.50}Ga_{0.50}N$ single p-n junction solar cell.

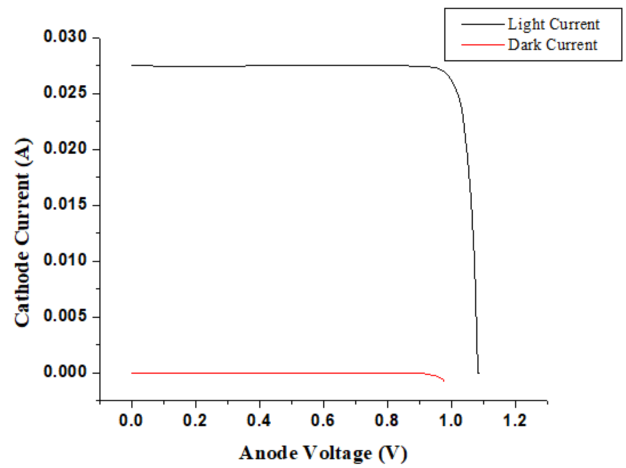


Fig. 4: Dark and Illuminated Characteristics for $In_{0.50}Ga_{0.50}N$ Solar cell

Dark region characteristics and illumination region characteristics have been shown in Fig.4. In this figure the cathode current vs. anode voltage of dark region is shown by red color and of illuminated region is by black color.

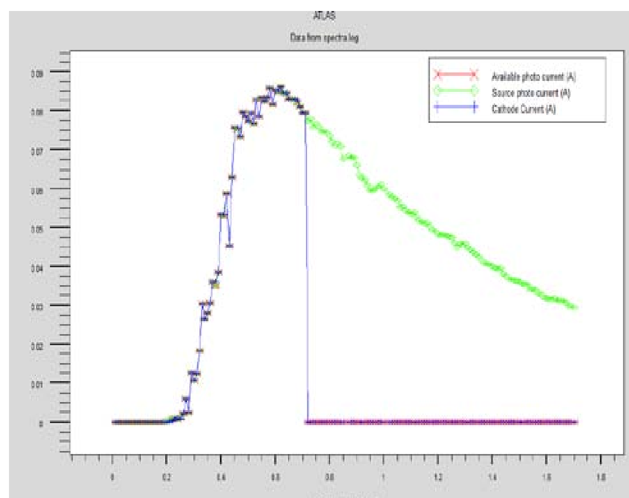


Fig. 5: Spectral Response for $In_{0.50}Ga_{0.50}N$ Solar cell

Spectral response with respect to wavelength has been shown above in Fig.5. Source photo current is maximum possible total current due to incident photons, available photo current is current due to total generated electron-hole pair and cathode current is total current collected at terminals. Among these three, source current is always greater than other two. Total photons incident losses due to reflection, transmission, thermalization etc. Further there is loss of some of the generated electron-hole pairs due to recombination and hence collected cathode current is less than or equal available photo current.

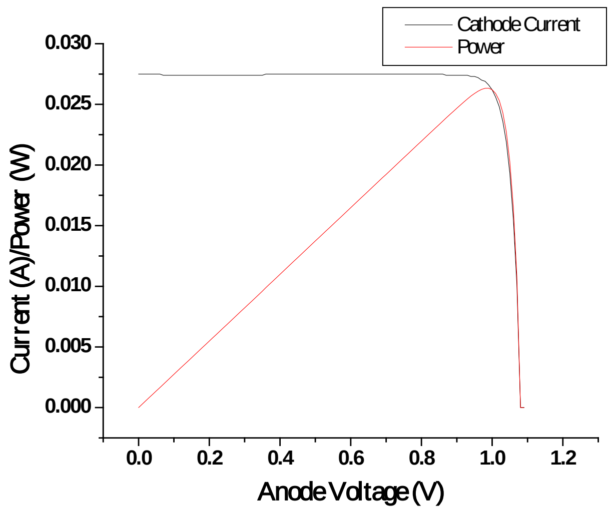
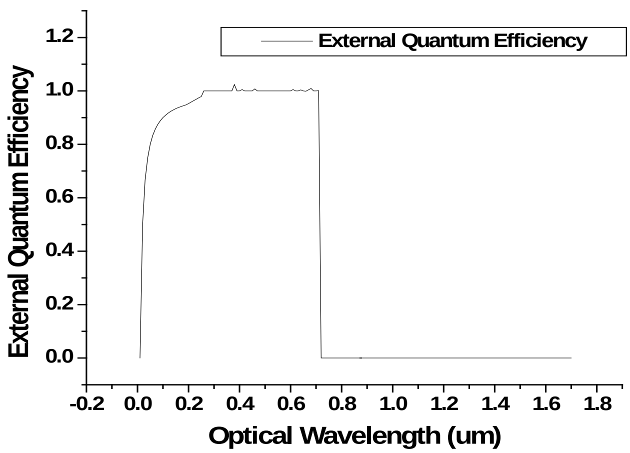
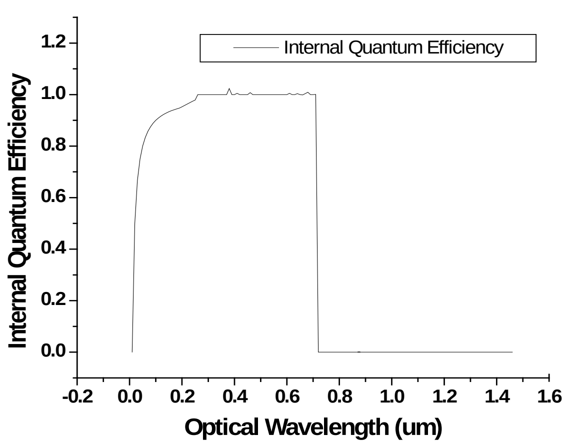


Fig. 6: VI & VP Characteristics for $In_{0.50}Ga_{0.50}N$ Solar cell

VI characteristics and VP characteristics has been shown in Fig6. In this figure the IV characteristics is shown by black color and of VP is by red color.



(a)



(b)

Fig. 7: Quantum efficiency Characteristics for $In_{0.50}Ga_{0.50}N$ Solar cell

Fig. 7(a) is shown for External Quantum Efficiency (EQE) that is defined as ratio of cathode current to source photo current and Fig.7(b) shows the Internal Quantum Efficiency (IQE) that is defined as ratio of cathode current to available photo current. Theoretically IQE is always greater than EQE hence justify the above graph.

IV. Conclusion

In this paper we report the TCAD simulation and performance optimization of $In_xGa_{(1-x)}N$ based solar cell. Evaluation of the performance of the device has been performed for various values of mole fraction x of In in InGaN. Extracted performance parameters such as current, voltage, power, fill factor and efficiency from the proposed structure are: open circuit voltage (V_{oc}) of 1.08 V, Short circuit current (I_{sc}) is 0.027A, Fill Factor (FF) is 88.58%, Maximum voltage (V_{max}) is 0.99 V, Maximum current (I_{max}) is 0.26A and overall efficiency is 19.36%.

Acknowledgement

The authors are thankful to SERB, DST Government of India for the financial support under the grant sanctioned for Project No.ECR/2017/000179.

References Références Referencias

1. Mesrane, F. Rahmoune, A. Mahrane and and A. Oulebsir " Design and Simulation of InGaNp-n Junction Solar Cell" Hindawi Publishing Corporation, International Journal of Photoenergy, Volume 2015, Article ID 594858, 9 pages
2. N. Akter, "Design and simulation of Indium Gallium Nitridemultijunction tandem solar cells," International Journal of Research in Engineering and Technology, vol. 3, no.1,pp. 315 321, 2014.
3. D. V. P. McLaughlin and J. M. Pearce, "Progress in indium gallium nitride materials for solar photovoltaic energy conversion," Metallurgical and Materials Transactions A: Physical Metallurgy and Materials Science,vol.44,no.4,pp.1947–1954,2013.
4. A.Mesrane, F. Rahmoune, A. Oulebsir, and A. Mahrane, "2D simulation study of In 0. 62 Ga 0. 38N solar cell structure," in Proceedings of the 2nd International Conference on Renewable Energy (CIER '14), vol. 99 of Proceedings of Engineering and Technolog y,2015.
5. F. Bouzid and S. Ben Machiche, "Potentials of InxGa1-xN photovoltaic tandems," Revue des Energies Renouvelables, vol.14,no.1,pp.47–56,2011.
6. Z. Li,H.Xiao, X. Wang et al., "T heoreticalsimulations of InGaN/Si mechanically stacked two-junction solar cell," Physica B: Condensed Matter, vol. 414, pp. 110–114, 2013.

7. L. A. Vilbois, A. Cheknane, A. Bensaoula, C. Boney, and T. Benouaz, "Simulation of a solar cell based on InGaN," Energy Procedia,vol.18,pp.795–806,2012.
8. F. Bouzid and L. Hamlaoui, "Investigation of InGaN/Si double junction tandem solar cells," Journal of Fundamental and Applied Sciences,vol.4,pp.59–71,2012.
9. M. Nawaz and A. Ahmad, "A TCAD-based modeling of GaN/InGaN/Si solar cells," Semiconductor Science and Technology, vol. 27, no. 3, Article ID 035019, 2012.
10. S. R. Kurtz, P. Faine, and J. M. Olson, "Modeling of two junction, series-connected tandem solar cells using top-cell thickness as an adjustable parameter," Journal of Applied Physics, vol. 68, no. 4, pp. 1890–1895, 1990.
11. M. Farahmand, C. Garetto, E. Bellotti et al., "Monte Carlo sim- ulation of electron transport in the III-nitride Wurtzite phase materials system: binaries and ternaries," IEEE Transactions on Electron Devices,vol.48,no.3,pp.535–542,2001.
12. M. Garozzo, A. Parretta, G. Maletta, V. Adoncecchi, and M. Gentili, "GaAs shallow homojunction solar cells fabricated on thin epitaxial films by a simple Zn solid state diffusion method," Solar Energy Materials,vol.14,no.1,pp.29–49,1986.
13. G. F. Brown, J. W. Ager III, W. Walukiewicz, and J. Wu, "Finite element simulations of compositionally graded InGaN solar cells," Solar Energy Materials & Solar Cells, vol. 94,no. 3, pp. 478–483, 2010.

This page is intentionally left blank

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 19 Issue 4 Version 1.0 Year 2019
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Low Probability of Intercept Triangular Modulated Frequency Modulated Continuous Wave Signal Characterization Comparison using the Wigner Ville Distribution and the Choi Williams Distribution

By Daniel L. Stevens

Abstract- Digital intercept receivers are currently moving away from Fourier-based analysis and towards classical timefrequency analysis techniques for the purpose of analyzing low probability of intercept radar signals. This paper presents the novel approach of characterizing low probability of intercept triangular modulated frequency modulated continuous wave radar signals through utilization and direct comparison of the Wigner Ville Distribution versus the Choi Williams Distribution. The following metrics were used for evaluation: percent error of: carrier frequency, modulation bandwidth, modulation period, chirp rate, and time-frequency localization (x and y direction). Also used were: percent detection, lowest signal-tonoise ratio for signal detection, and plot (processing) time. Experimental results demonstrate that overall, the Wigner Ville Distribution produced more accurate characterization metrics than the Choi Williams Distribution. An improvement in performance may well translate into an increase in personnel safety.

GJRE-F Classification: FOR Code: 040401

Low Probability of Intercept Triangular Modulated Frequency Modulated Continuous Wave Signal Characterization Comparison using the Wigner Ville Distribution and the Choi Williams Distribution

Daniel L. Stevens

Abstract- Digital intercept receivers are currently moving away from Fourier-based analysis and towards classical time-frequency analysis techniques for the purpose of analyzing low probability of intercept radar signals. This paper presents the novel approach of characterizing low probability of intercept triangular modulated frequency modulated continuous wave radar signals through utilization and direct comparison of the Wigner Ville Distribution versus the Choi Williams Distribution. The following metrics were used for evaluation: percent error of: carrier frequency, modulation bandwidth, modulation period, chirp rate, and time-frequency localization (x and y direction). Also used were: percent detection, lowest signal-to-noise ratio for signal detection, and plot (processing) time. Experimental results demonstrate that overall, the Wigner Ville Distribution produced more accurate characterization metrics than the Choi Williams Distribution. An improvement in performance may well translate into an increase in personnel safety.

I. Introduction

Frequency Modulated Continuous Wave (FMCW)signals are frequently encountered in modern radar systems [WAN10], [WON09], [WAJ08]. The frequency modulation spreads the transmitted energy over a large modulation bandwidth ΔF, providing good range resolution that is critical for discriminating targets from clutter. The power spectrum of the FMCW signal is nearly rectangular over the modulation bandwidth, so non-cooperative interception is difficult. Since the transmit waveform is deterministic, the form of the return signals can be predicted. This gives it the added advantage of being resistant to interference (such as jamming), since any signal not matching this form can be suppressed [WIL06]. Consequently, it is difficult for an intercept receiver to detect the FMCW waveform and measure the parameters accurately enough to match the jammer waveform to the radar waveform [PAC09].

The most popular linear modulation utilized is the triangular FMCW emitter [LIA09], since it can measure the target's range and Doppler [MIL02], [LIW08]. Triangular modulated FMCW is the waveform that is employed in this paper.

Time-frequency signal analysis involves the analysis and processing of signals with time-varying frequency content. Such signals are best represented by a time-frequency distribution [PAP95], [HAN00], which is intended to show how the energy of the signal is distributed over the two-dimensional time-frequency plane [WEI03], [LIX08], [OZD03]. Processing of the signal may then exploit the features produced by the concentration of signal energy in two dimensions (time and frequency), instead of only one dimension (time or frequency) [BOA03], [LIY03]. Since noise tends to spread out evenly over the time-frequency domain, while signals concentrate their energies within limited time intervals and frequency bands; the local SNR of a 'noisy' signal can be improved simply by using time-frequency analysis [XIA99]. Also, the intercept receiver can increase its processing gain by implementing time-frequency signal analysis [GUL08].

Time-frequency distributions are useful for the visual interpretation of signal dynamics [RAN01]. An experienced operator can quickly detect a signal and extract the signal parameters by analyzing the time-frequency distribution [ANJ09].

Wigner Ville Distribution (WVD)

One of the most prominent members of the time-frequency analysis techniques family is the WVD. The WVD satisfies a large number of desirable mathematical properties. In particular, it is always real-valued, preserves time and frequency shifts, and satisfies marginal properties [QIA02]. The WVD, which is a transformation of a continuous time signal into the time-frequency domain, is computed by correlating the signal with a time and frequency translated version of itself, making it bilinear. The WVD exhibits the highest signal energy concentration in the time-frequency plane [WIL06]. By using the WVD, an intercept receiver can come close to having a processing gain near the LPI radar's matched filter processing gain [PAC09]. The

Author: Air Force Research Laboratory Rome.
e-mail: daniel.stevens.7@us.af.mil

WVD also contains cross term interference between every pair of signal components, which may limit its applications [GUL07], [STE96], and which can make the WVD time-frequency representation hard to read, especially if the components are numerous or close to each other, and the more so in the presence of noise [BOA03]. This lack of readability can in turn translate into decreased signal detection and parameter extraction metrics, potentially placing the intercept receiver signal analyst's platform in harm's way.

The WVD of a signal $x(t)$ is given in equation (1) as:

$$W_x(t,f) = \int_{-\infty}^{+\infty} x(t+\frac{\tau}{2})x^*\left(t-\frac{\tau}{2}\right)e^{-j2\pi f\tau}\,d\tau \tag{1}$$

or equivalently in equation (2) as:

$$W_x(t,f) = \int_{-\infty}^{+\infty} X(f+\frac{\xi}{2})X^*\left(f-\frac{\xi}{2}\right)e^{j2\pi\xi t}\,d\xi \tag{2}$$

Choi Williams Distribution (CWD)

The CWD is a member of the Cohen's class of time-frequency distributions which use smoothing kernels [GUL07] to help reduce cross-term interference so prevalent in the WVD [BOA03], [PAC09], [UPP08]. The reduction in cross-term interference can make the time-frequency representation more readable and can make signal detection and parameter extraction more accurate. The down side is that the CWD, like all members of Cohen's class, is faced with an inevitable trade-off between cross-term reduction and time-frequency localization. Because of this, the signal detection and parameter extraction benefits gained by the cross-term reduction may be offset by the decrease in time-frequency localization (smearing or widening of the signal).

The CWD of a signal $x(s)$is given in equation (3) as:

$$CW_x(t,f) = \sqrt{\frac{2}{\pi}}\iint_{-\infty}^{+\infty} \frac{\sigma}{|\tau|}e^{-2\sigma^2(s-t)^2/\tau^2}\,x\left(s+\frac{\tau}{2}\right)x^*\left(s-\frac{\tau}{2}\right)e^{-j2\pi f\tau}\,ds\,d\tau \tag{3}$$

As can be seen from equation (3), the CWD uses an exponential kernel in the generalized class of bilinear time-frequency distributions. Choi and Williams introduced one of the earliest 'new' distributions [CHO89], which they called the Exponential Distribution or ED. This new distribution overcomes several drawbacks of the Spectrogram and the WVD, providing a good trade-off between localization and suppressed interferences [WIL92], [GUL07], [UPP08]. Interference terms tend to lie away from the axes in the ambiguity plane, while auto terms (signals) tend to lie on the axes. The Spectrogram kernel attenuates everything away from the $(0,0)$ point, the WVD kernel passes everything, and the CWD kernel passes everything on the axes and attenuates away from the axes. Thus, the CWD generally attenuates interference terms [PAC09], [HLA92]. This provides its reduced interference characteristic. The Spectrogram reduces interference also, but at a cost to the signal concentration.

II. Methodology

The methodologies detailed in this section describe the processes involved in obtaining and comparing metrics between the classical time-frequency analysis techniques of the Wigner Ville Distribution and the Choi Williams Distribution for the detection and characterization of low probability of intercept triangular modulated FMC Wradar signals.

The tools used for this testing were: MATLAB (version 8.3), Signal Processing Toolbox (version 6.21), Wavelet Toolbox (version 4.13), Image Processing Toolbox (version 9.0), Time-Frequency Toolbox (version 1.0) (http://tftb.nongnu.org/).

All testing was accomplished on a desktop computer (Dell Precision T1700; Processor -Intel Xeon CPU E3-1226 v3 3.30GHz; Installed RAM - 32.0GB; System type - 64-bit operating system, x64-based processor).

Testing was performed for the triangular modulated FMCW waveform, whose parameters were chosen for academic validation of signal processing techniques. Due to computer processing resources they were not meant to represent real-world values. The number of samples was chosen to be either 256 or 512, which seemed to be the optimum size for the desktop computer. Testing was performed at three different SNR levels: 10dB, 0dB, and the lowest SNR at which the signal could be detected. The noise added was white Gaussian noise, which best reflects the thermal noise present in the IF section of an intercept receiver [PAC09]. Kaiser windowing was used, when windowing was applicable. 100 runs were performed for each test, for statistical purposes. The plots included in this paper were done at a threshold of 5% of the maximum intensity and were linear scale (not dB) of analytic (complex) signals; the color bar represented intensity.

The signal processing tools used for each task were the Wigner Ville Distribution and the Choi Williams Distribution.

The triangular modulated FMCW signal (most prevalent LPI radar waveform [LIA09]) used had the following parameters: sampling frequency = 4 KHz; carrier frequency = 1 KHz; modulation bandwidth = 500Hz; modulation period =. 02 sec.

After each particular run of each test, metrics were extracted from the time-frequency representation. The different metrics extracted were as follows:

a) Plot (processing) time

Time required for plot to be displayed.

b) Percent detection

Percent of time signal was detected - signal was declared a detection if any portion of each of the signal components (4 chirp components for triangular modulated FMCW) exceeded a set threshold (a certain percentage of the maximum intensity of the time-frequency representation).

Threshold percentages were determined based on visual detections of low SNR signals (lowest SNR at which the signal could be visually detected in the time-frequency representation) (see Figure 1).

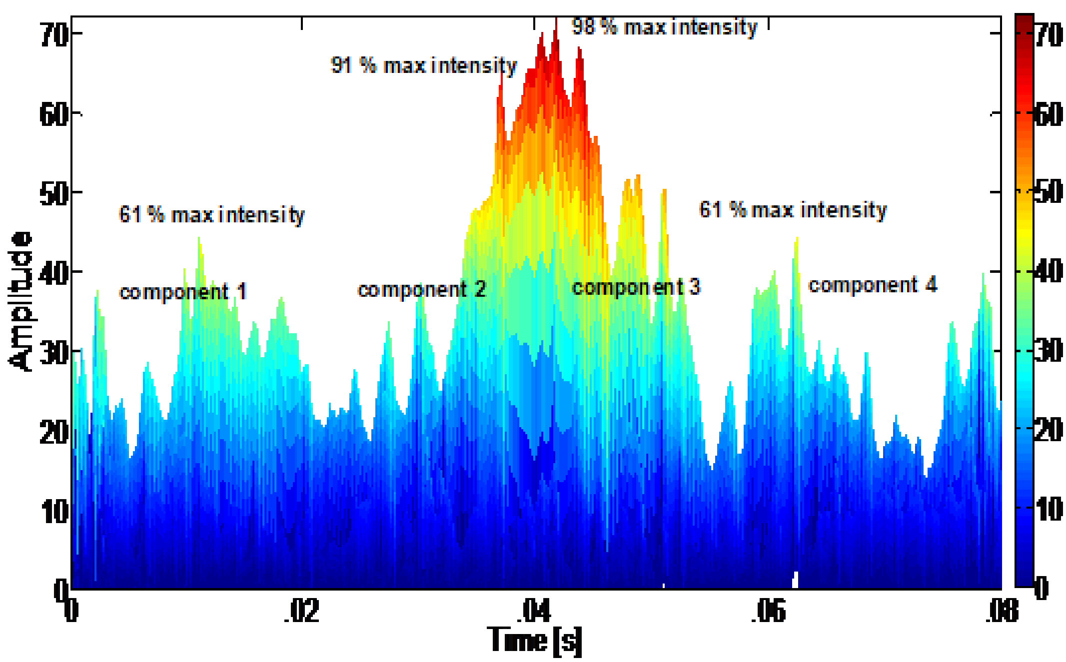


Figure 1: Threshold percentage determination. This plot is a time vs. amplitude (x-z view) of the CWD of a triangular modulated FMCW signal (256 samples, with SNR= -3dB). For visually detected low SNR plots (like this one), the percent of max intensity for the peak z-value of each of the signal components (the 2 legs for each of the 2 triangles of the triangular modulated FMCW) was noted (here 61%, 91%, 98%, 61%), and the lowest of these 4 values was recorded (61%). Ten test runs were performed for both time-frequency analysis tools (CWD and WVD) for this waveform. The average of these recorded low values was determined and then assigned as the threshold for that particular time-frequency analysis tool. Note - the threshold for the CWD is 60%.

Thresholds were assigned as follows: CWD (60%); WVD (50%).

For percent detection determination, these threshold values were included in the time-frequency plot algorithms so that the thresholds could be applied automatically during the plotting process. From the threshold plot, the signal was declared a detection if any portion of each of the signal components was visible (see Figure 2).

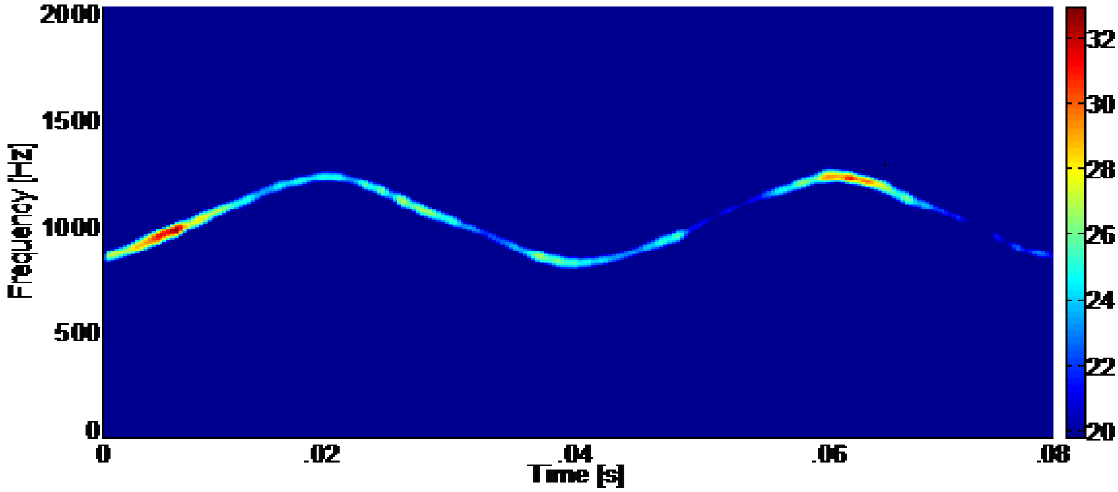


Figure 2: Percent detection (time-frequency). This plot is a time vs. frequency (x-y view) of the CWD of a triangular modulated FMCW signal (256 samples, with SNR= 10dB) with threshold value automatically set to 60%. From this threshold plot, the signal was declared a (visual) detection because at least a portion of each of the 4 signal components (the 2 legs for each of the 2 triangles of the triangular modulated FMCW) was visible.

c) Carrier frequency

The frequency corresponding to the maximum intensity of the time - frequency representation (see Figure 3).

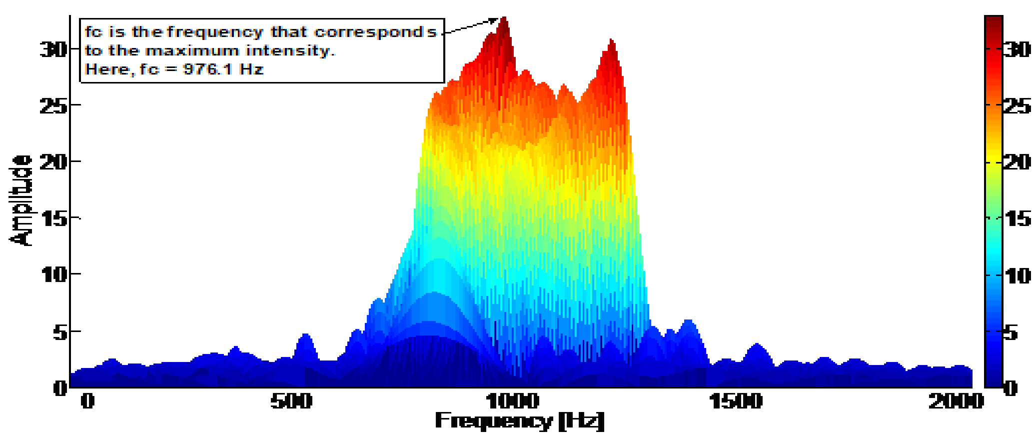


Figure 3: Determination of carrier frequency. CWD of a triangular modulated FMCW signal (256 samples, SNR=10dB). From the frequency vs. amplitude (y-z view), the maximum intensity value is manually determined. The frequency corresponding to the max intensity value is the carrier frequency (here fc=976.1 Hz).

d) Modulation bandwidth

Distance from highest frequency value of signal (at a threshold of 20% maximum intensity) to lowest frequency value of signal (at same threshold) in Y-direction (frequency).

The threshold percentage was determined based on manual measurement of the modulation bandwidth of the signal in the time-frequency representation. This was accomplished for ten test runs of each time-frequency analysis tool (Wigner Ville Distribution and Choi Williams Distribution), for the triangular modulated FMCW waveform. During each manual measurement, the max intensity of the high and low measuring points was recorded. The average of the max intensity values for these test runs was 20%. This was adopted as the threshold value, and is representative of what is obtained when performing manual measurements. This 20% threshold was also adapted for determining the modulation period and the time-frequency localization (both are described below).

For modulation bandwidth determination, the 20% threshold value was included in the time-frequency plot algorithms so that the threshold could be applied automatically during the plotting process. From the threshold plot, the modulation bandwidth was manually measured (see Figure 4).

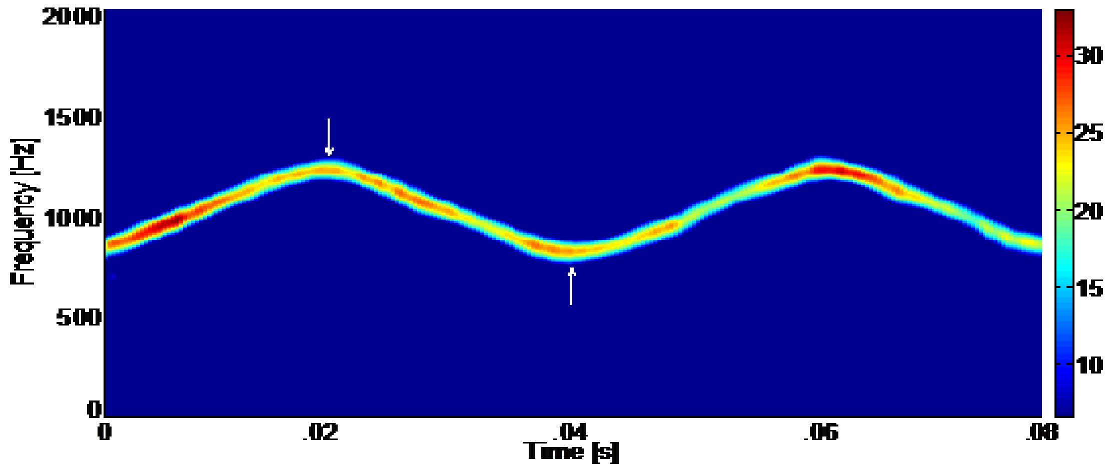


Figure 4: Modulation bandwidth determination. This plot is a time vs. frequency (x-y view) of the CWD of a triangular modulated FMCW signal (256 samples, SNR=10dB) with threshold value automatically set to 20%. From this threshold plot, the modulation bandwidth was measured manually from the highest frequency value of the signal (top white arrow) to the lowest frequency value of the signal (bottom white arrow) in the y direction (frequency).

e) Modulation period

Distance from highest frequency value of signal (at a threshold of 20% maximum intensity) to lowest frequency value of signal (at same threshold) in X-direction (time).

For modulation period determination, the 20% threshold value was included in the time-frequency plot algorithms so that the threshold could be applied automatically during the plotting process. From the threshold plot, the modulation period was manually measured (see Figure 5).

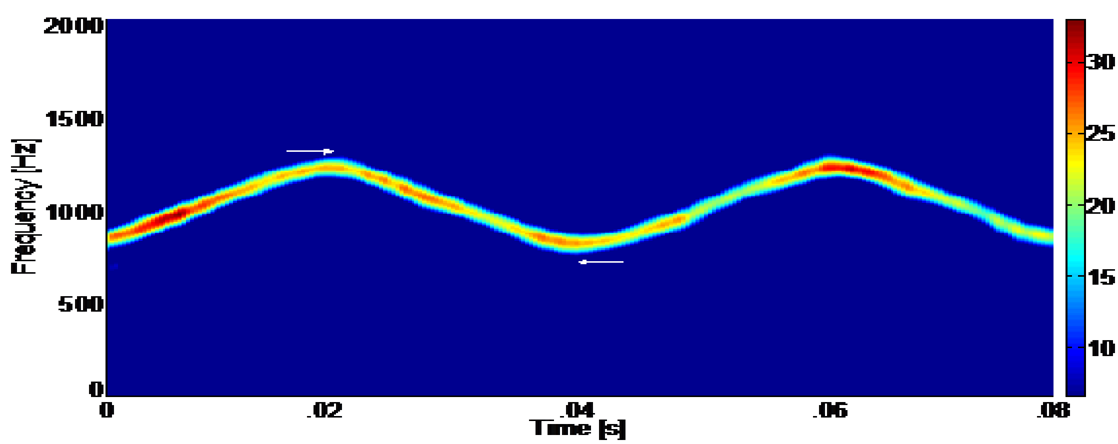


Figure 5: Modulation period determination. This plot is a time vs. frequency (x-y view) of the CWD of a triangular modulated FMCW signal (256 samples, SNR=10dB) with threshold value automatically set to 20%. From this threshold plot, the modulation period was measured manually from the highest frequency value of the signal (top white arrow) to the lowest frequency value of the signal (bottom white arrow) in the x-direction (time).

f) Time-frequency localization

Measure of the thickness of a signal component (at a threshold of 20% maximum intensity on each side of the component) – converted to % of entire X-Axis, and % of entire Y-Axis.

For time-frequency localization determination, the 20% threshold value was included in the time-frequency plot algorithms so that the threshold could be applied automatically during the plotting process. From the threshold plot, the time-frequency localization was manually measured (see Figure 6).

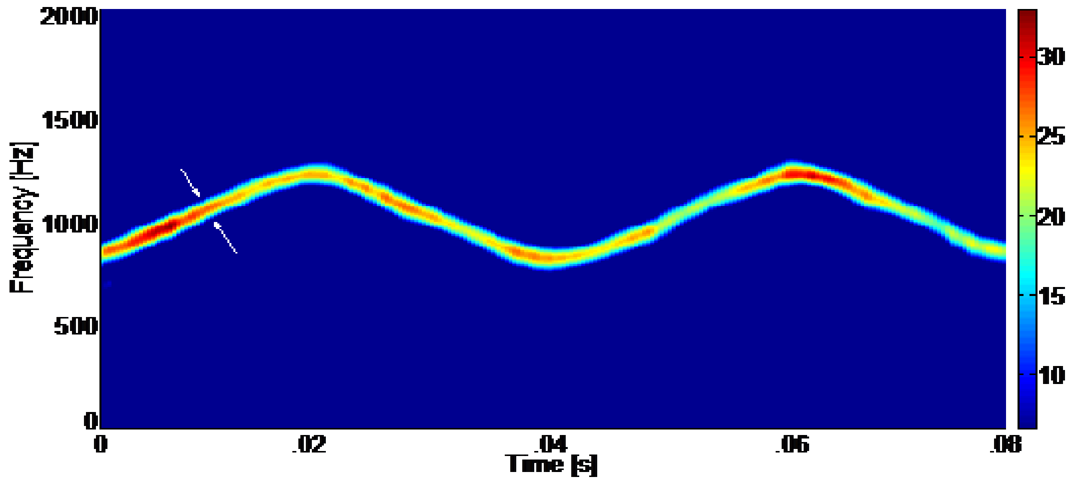


Figure 6: Time-frequency localization determination. This plot is a time vs. frequency (x-y view) of the CWD of a triangular modulated FMCW signal (256 samples, SNR=10dB) with threshold value automatically set to 20%. From this threshold plot, the time-frequency localization was measured manually from the left side of the signal (left white arrow) to the right side of the signal (right white arrow) in both the x-direction (time) and the y-direction (frequency). Measurements were made at the center of each of the 4 'legs', and the average values were determined. Average time and frequency 'thickness' values were then converted to: % of entire x-axis and % of entire y-axis.

g) Chirp rate

(modulation bandwidth)/(modulation period)

h) Lowest detectable SNR

The lowest SNR level at which at least a portion of each of the signal components exceeded the set threshold listed in the percent detection section above.

For lowest detectable SNR determination, these threshold values were included in the time-frequency plot algorithms so that the thresholds could be applied automatically during the plotting process. From the threshold plot, the signal was declared a detection if any portion of each of the signal components was visible. The lowest SNR level for which the signal was declared a detection is the lowest detectable SNR (see Figure 7).

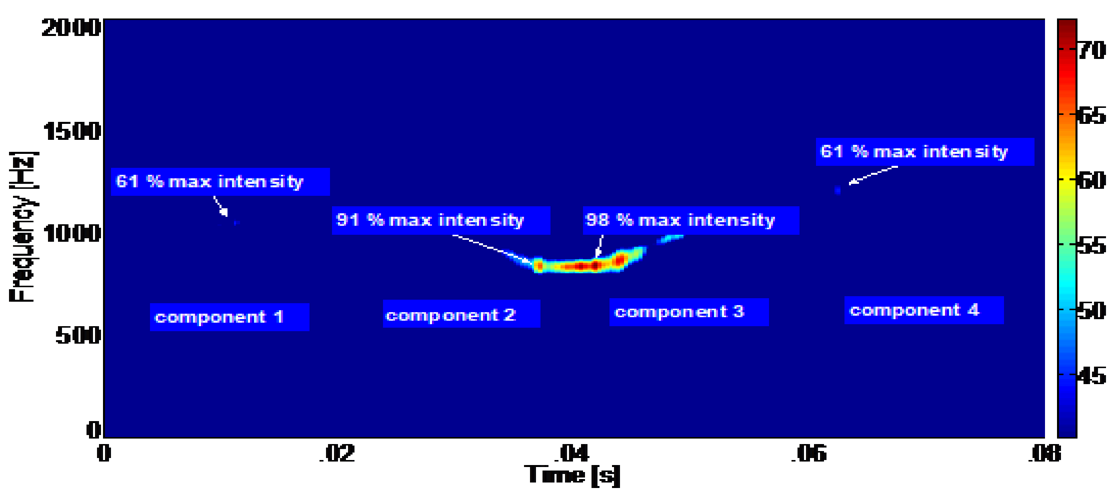


Figure 7: Lowest detectable SNR. This plot is a time vs. frequency (x-y view) of the CWD of a triangular modulated FMCW signal (256 samples, with SNR= -3dB) with threshold value automatically set to 60%. From this threshold plot, the signal was declared a (visual) detection because at least a portion of each of the 4 signal components (the 2 legs for each of the 2 triangles of the triangular modulated FMCW) was visible. Note that the signal portion for the two 61% max intensities are barely visible, because the threshold for the CWD is 60%. For this case, any lower SNR than -3dB would have been a non-detect.

The data from all 100 runs for each test was used to produce the actual, error, and percent error for each of these metrics listed above.

The metrics from the Wigner Ville Distribution were then compared to the metrics from the Choi Williams Distribution. By and large, the Wigner Ville Distribution outperformed the Choi Williams Distribution, as will be shown in the results section.

III. Results

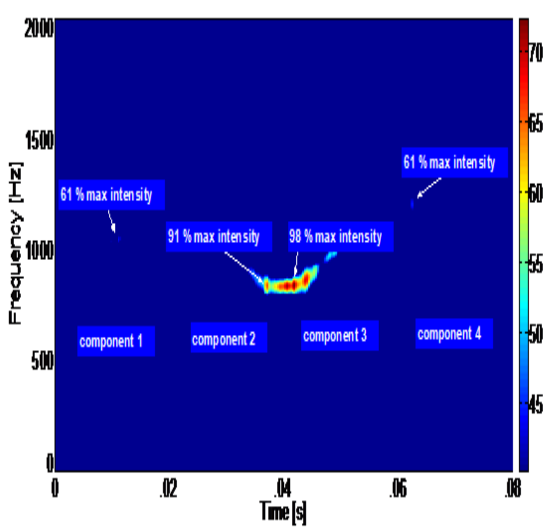
Table 1 presents the overall test metrics for the two classical time-frequency analysis techniques used in this testing (Choi Williams Distribution versus Wigner Ville Distribution).

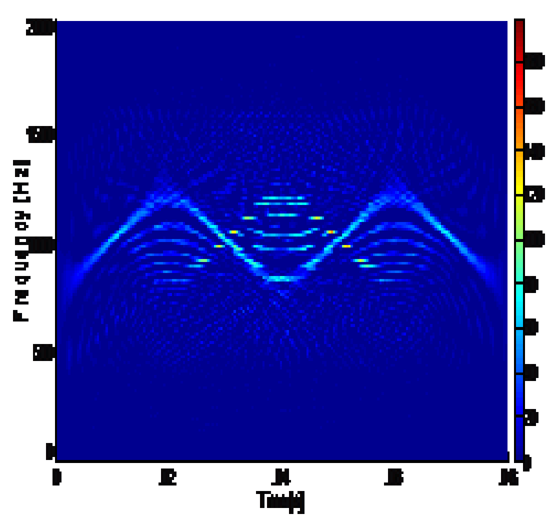
Table 1: Overall test metrics (average percent error: carrier frequency, modulation bandwidth, modulation period, chirp rate; average: percent detection, lowest detectable snr, plot time, time-frequency localization (as a percent of x axis and y axis) for the two classical time-frequency analysis techniques (Choi Williams Distribution versus Wigner Ville Distribution).

Parameters	Choi Williams Distribution	Wigner Ville Distribution
carrier frequency	5.22%	2.23%
modulation bandwidth	9.61%	5.53%
modulation period	0.49%	0.48%
chirp rate	9.67%	5.28%
percent detection	69.6%	77.6%
lowest detectable snr	-3.0db	-2.3db
plot time	10.44s	1341.84s
time-frequency localization-x	1.89%	0.62%
time-frequency localization-y	3.52%	1.28%

From Table 1, the WVD outperformed the CWD in average percent error: carrier frequency (2.23% vs. 5.22%), modulation bandwidth (5.53% vs. 9.61%), modulation period (0.48% vs. 0.49%), and chirp rate (5.28% vs. 9.67%). The WVD also outperformed the CWD in average: percent detection (77.6% vs. 69.6%), time-frequency localization (x-direction) (0.62% vs. 1.89%), and time-frequency localization (y-direction) (1.28% vs. 3.52%). The CWD outperformed the WVD in average: lowest detectable SNR (-3.0db vs. -2.3db) and average plot time (10.44s vs. 1341.84s).

Figure 8 shows comparative plots of the Choi Williams Distribution (left) vs. the Wigner Ville Distribution (right) (triangular modulated FMCW signal) at SNRs of 10dB (top row), 0dB (middle row), and -3dB (bottom row).





Global Journal of Researches in Engineering (F) Volume XIX Issue IV Version I Year 2019

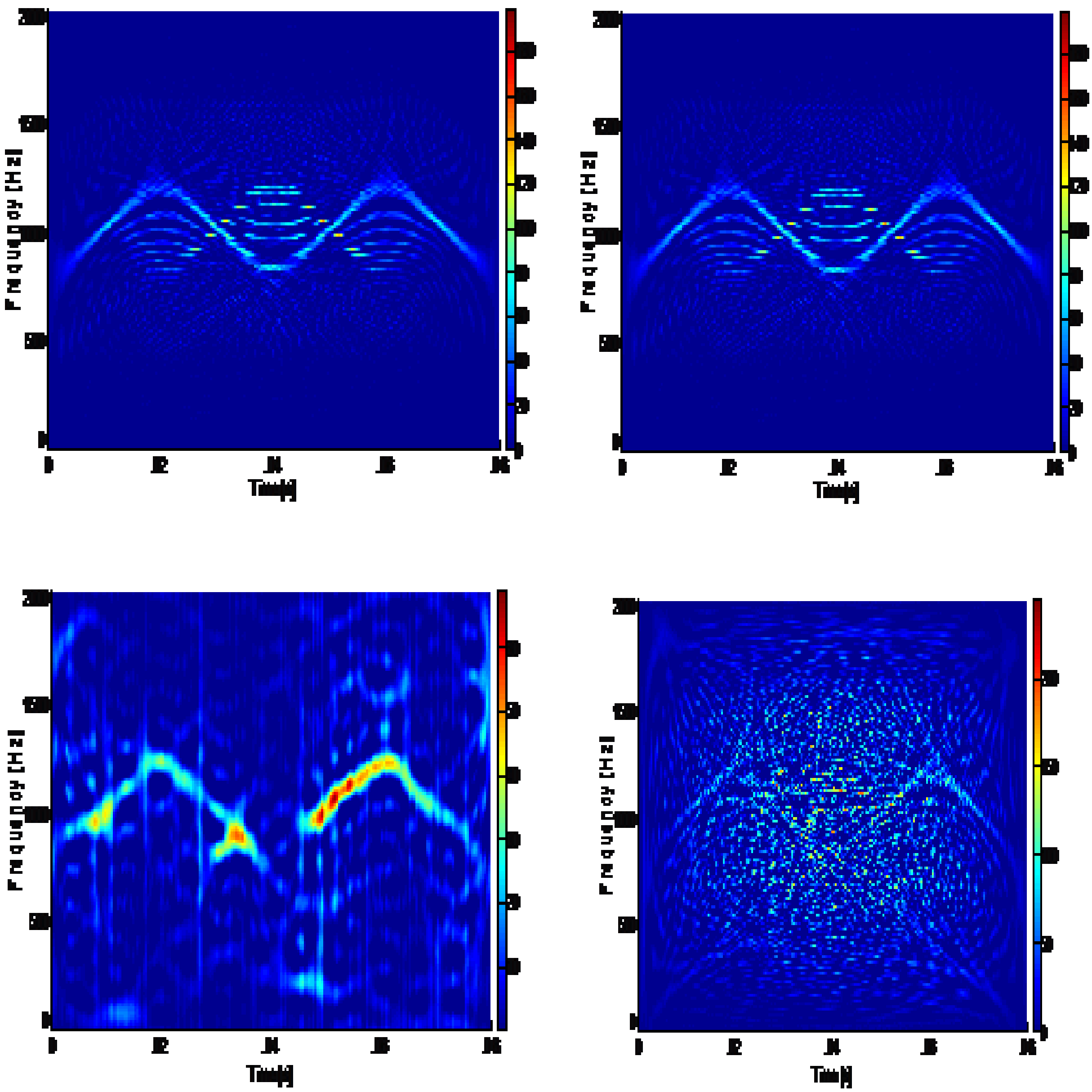


Figure 8: Comparative plots of the triangular modulated FMCWlow probability of intercept radar signals (CWD (left-hand side) vs. the WVD (right-hand side)). The SNR for the top row is 10dB, for the middle row is 0dB, and for the bottom row is -3dB.In general, the WVD signalappears more localized ('thinner') than does the CWD signal, however, the cross-term interference in the WVDplots makes it more difficult to differentiate betweeen the signal and the cross-term interference.

IV. Discussion

This section will elaborate on the results from the previous section.

From Table 1, the WVD outperformed the CWD in average percent error: carrier frequency (2.23% vs. 5.22%), modulation bandwidth (5.53% vs. 9.61%), modulation period (0.48% vs. 0.49%), and chirp rate (5.28% vs. 9.67%); and in average: percent detection (77.6% vs. 69.6%), time-frequency localization (x-direction) (0.62% vs. 1.89%), and time-frequency localization (y-direction) (1.28% vs. 3.52%). These results are by and large a result of the WVD signal being much more localized signal than the CWD signal. The CWD's 'thicker' signal is a result of its cross-term reduction - at the expense of signal localization.

The CWD outperformed the WVD in average: lowest detectable SNR (-3.0db vs. -2.3db) and average plot time (10.44s vs. 1341.84s). The combination of the CWD's reduction of cross-term interference along with the WVD being very computationally complex [MIL02] are the grounds for the CWD's better plot time. In addition, lowest detectable SNR is based on visual detection in the Time-Frequency representation. Figure 8 shows that, for the WVD plots, as the SNR gets lower, it becomes more difficult to distinguish between the actual signal and the cross-term interference. However, for the CWD plots there is no cross-term interference to confuse with the actual signals, making the CWD signal, though not as localized, more easily detected than the WVD signal - at these lower SNRs.

The WVD might be used in a scenario where you need good signal localization in a fairly low SNR environment, without tight time constraints. The CWD might be used in a scenario where a short plot time is necessary, and where signal localization is not an issue. Such a scenario might be a 'quick and dirty' check to see if a signal is present, without precise extraction of its parameters.

V. Conclusions

Digital intercept receivers, whose main job is to detect and extract parameters from low probability of intercept radar signals, are currently moving away from Fourier-based analysis and towards classical time-frequency analysis techniques, such as the Wigner Ville Distribution, and the Choi Williams Distribution, for the purpose of analyzing low probability of intercept radar signals. Based on the research performed for this paper (the novel direct comparison of the Wigner Ville Distribution versus the Choi Williams Distribution for the signal analysis of low probability of intercept triangular modulated FMCW radar signals) it was shown that the Wigner Ville Distribution by-and-large outperformed the Choi Williams Distribution for analyzing these low probability of intercept radar signals - for reasons brought out in the discussion section above. More accurate characterization metrics could well translate into saved equipment and lives.

Future plans include continuing to analyze low probability of intercept radar waveforms (such as the frequency hopping and the triangular modulated FMCW), using additional time-frequency analysis techniques.

References Références Referencias

1. [ANJ09] Anjaneyulu, L., Murthy, N., Sarma, N., A Novel Method for Recognition of Modulation Code of LPI Radar Signals. International Journal of Recent Trends in Engineering, Vol.1,No.3, pp.176-180, May 2009.
2. [BOA03] Boashash, B., Time Frequency Signal Analysis and Processing: A Comprehensive Reference. Elsevier, Oxford, England, 2003.
3. [CHO89] Choi, H., Williams, W., Improved Time-Frequency Representation of Multicomponent Signals Using Exponential Kernels. IEEE Transactions on Acoustics, Speech, and Signal Processing. Vol.37,pp.862-871,June 1989.
4. [GUL07] Gulum, T., Autonomous Non-Linear Classifications of LPI Radar Signal Modulations. Thesis, Naval Postgraduate School, Monterey, CA, 2007.
5. [GUL08] Gulum, T., Pace, P., Cristi, R., Extraction of Polyphase Radar Modulation Parameters Using a Wigner-Ville Distribution-Radon Transform. IEEE International Conference on Acoustics, Speech, and Signal Processing, Las Vegas, NV, April 2008.
6. [HAN00] Han, S., Hong, H., Seo, D., Choi, J., Target Position Extraction Based on Instantaneous Frequency Estimation in a Fixed-Reticle Seeker. Opt. Eng., Vol. 39, pp. 2568-2573, September 2000.
7. [HLA92] Hlawatsch, F., Boudreaux-Bartels, G.F., Linear and Quadratic Time-Frequency Signal Representations. IEEE Signal Processing Mag., Vol. 9, No.2,pp.21-67,April1992.
8. [LIA09] Liang, Y., Zhang, L., Xing, M., Bao, Z., High-Speed Ground Moving Target Detection Research Using Triangular Modulation FMCW. Front. Electr. Electron. Eng., China, 4(2), pp. 127-133, 2009.
9. [LIW08] Li, W., Dan, M., Wang, X., Li, D., Wang, G., Fast Estimation Method and Performance Analysis of Frequency Modulation Rate Via RAT. Proceedings of the 2008 IEEE International Conference on Information and Automation, Zhangjiajie, China, pp. 144-147, June 20-23, 2008.
10. [LIX08] Li, X., Bi, G., A New Reassigned Time-Frequency Representation. 16th European Signal Processing Conference, Lausanne, Switzerland, pp. 1-4, August 25-29, 2008.
11. [LIY03] Li, Y., Xiao, X., Recursive Filtering Radon-Ambiguity Transform Algorithm for Detecting Multi-LFM Signals. Journal of Electronics (China), Vol.20,No.3,pp.161-166,May 2003.
12. [MIL02] Milne, P., Pace, P., Wigner Distribution Detection and Analysis of FMCW and P-4 Polyphase LPI Waveforms. Proceedings of ICASSP, Orlando, FL, pp. 3944-3947, 2002.
13. [OZD03] Ozdemir, A., Time-Frequency Component Analyzer. Dissertation, Bilkent University, Ankara, Turkey, Sept. 2003.
14. [PAC09] Pace, P., Detecting and Classifying Low Probability of Intercept Radar. Artech House, Norwood, MA, 2009.

15. [PAP95] Papandreou, A., Boudreaux-Bartels, G. F., Kay, S., Detection and Estimation of Generalized Chirps Using Time-Frequency Representations. 1994 Conference Record of the Twenty-Eighth Asilomar Conference on Signals, Systems and Computers, pp. 50-54, 1994.
16. [QIA02] Qian, S., Introduction To Time-Frequency and Wavelet Transforms. Prentice Hall, Upper River, NJ, 2002.
17. [RAN01] Rangayyan, R., Krishnan, S., Feature Identification in the Time-Frequency Plane by Using the Hough-Radon Transform. Pattern Recognition, Vol. 34, pp. 1147-1158, 2001.
18. [STE96] Stephens, J., Advances in Signal Processing Technology for Electronic Warfare. IEEE AES Systems Magazine, pp. 31-38, November 1996.
19. [UPP08] Upperman, T., ELINT Signal Processing Using Choi-Williams Distribution on Reconfigurable Computers for Detection and Classification of LPI Emitters. Thesis, Naval Postgraduate School, Monterey, CA, March 2008.
20. [WAJ08] Wang, Y., Jiang, Y., Detection and Parameter Estimation of Multicomponent LFM Signal Based on the Cubic Phase Function. EURASIP Journal on Advances in Signal Processing, Vol. 2008, Article ID 743985, pp. 1-7, 2008
21. [WAN10] Wang, P., Li, H., Djurovic, I., Himed, B., Integrated Cubic Phase Function for Linear FM Signal Analysis. IEEE Transactions on Aerospace and Electronic Systems, to appear, 2010.
22. [WEI03] Wei, G., Wu, S., Mao, E., Analysis of Multicomponent LFM Signals Using Time-Frequency and the Gray-Scale Inverse Hough Transform. IEEE Workshop on Statistical Signal Processing, pp. 190-193, September 28 – October 1, 2003.
23. [WIL06] Wiley, R., ELINT: The Interception and Analysis of Radar Signals. Artech House, Norwood, MA, 2006.
24. [WIL92] Williams, W., Jeong, J., Reduced Interference Time-Frequency Distributions. Time-Frequency Signal Analysis: Methods and Applications (B. Boashash, ed.), Longman-Cheshire/Wiley, Melbourne/N.Y., 1992.
25. [WON09] Wong, K., Davidson, T., Abelkader, S., Detection of Low Probability of Intercept Radar Signals. Defence R&D Canada – Ottawa Contract Report 2009-142, September 2009.
26. [XIA99] Xia, X., Chen, V., A Quantitative SNR Analysis for the Pseudo Wigner-Ville Distribution. IEEE Transactions on Signal Processing, Vol.47, No.10,pp.2891-2894,October, 1999.

Global Journals Guidelines Handbook 2019

www.GlobalJournals.org

Fellows

FELLOW OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (FARSE)

Global Journals Incorporate (USA) is accredited by Open Association of Research Society (OARS), U.S.A and in turn, awards "FARSE" title to individuals. The 'FARSE' title is accorded to a selected professional after the approval of the Editor-in-Chief /Editorial Board Members/Dean.

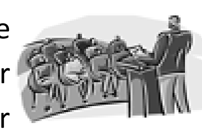
- The "FARSE" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSE or William Walldroff, M.S., FARSE.

FARSE accrediting is an honor. It authenticates your research activities. After recognition as FARSE, you can add 'FARSE' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, and Visiting Card etc.

The following benefits can be availed by you only for next three years from the date of certification:

FARSE designated members are entitled to avail a 40% discount while publishing their research papers (of a single author) with Global Journals Incorporation (USA), if the same is accepted by Editorial Board/Peer Reviewers. If you are a main author or co-author in case of multiple authors, you will be entitled to avail discount of 10%.

Once FARSE title is accorded, the Fellow is authorized to organize a symposium/seminar/conference on behalf of Global Journal Incorporation (USA).The Fellow can also participate in conference/seminar/symposium organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent.

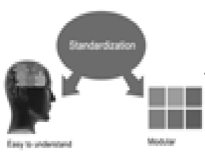


You may join as member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. In addition, it is also desirable that you should organize seminar/symposium/conference at least once.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The FARSE can go through standards of OARS. You can also play vital role if you have any suggestions so that proper amendment can take place to improve the same for the benefit of entire research community.

As FARSE, you will be given a renowned, secure and free professional email address with 100 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.



The FARSE will be eligible for a free application of standardization of their researches. Standardization of research will be subject to acceptability within stipulated norms as the next step after publishing in a journal. We shall depute a team of specialized research professionals who will render their services for elevating your researches to next higher level, which is worldwide open standardization.

The FARSE member can apply for grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A. Once you are designated as FARSE, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria. After certification of all your credentials by OARS, they will be published on your Fellow Profile link on website https://associationofresearch.org which will be helpful to upgrade the dignity.

The FARSE members can avail the benefits of free research podcasting in Global Research Radio with their research documents. After publishing the work, (including published elsewhere worldwide with proper authorization) you can upload your research paper with your recorded voice or you can utilize chargeable services of our professional RJs to record your paper in their voice on request.

The FARSE member also entitled to get the benefits of free research podcasting of their research documents through video clips. We can also streamline your conference videos and display your slides/ online slides and online research video clips at reasonable charges, on request.

The FARSE is eligible to earn from sales proceeds of his/her researches/reference/review Books or literature, while publishing with Global Journals. The FARSE can decide whether he/she would like to publish his/her research in a closed manner. In this case, whenever readers purchase that individual research paper for reading, maximum 60% of its profit earned as royalty by Global Journals, will be credited to his/her bank account. The entire entitled amount will be credited to his/her bank account exceeding limit of minimum fixed balance. There is no minimum time limit for collection. The FARSE member can decide its price and we can help in making the right decision.

The FARSE member is eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get remuneration of 15% of author fees, taken from the author of a respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account.

MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (MARSE)

The ' MARSE ' title is accorded to a selected professional after the approval of the Editor-in-Chief / Editorial Board Members/Dean.

The “MARSE” is a dignified ornament which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., MARSE or William Walldroff, M.S., MARSE.

MARSE accrediting is an honor. It authenticates your research activities. After becoming MARSE, you can add 'MARSE' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

The following benefitscan be availed by you only for next three years from the date of certification.

MARSE designated members are entitled to avail a 25% discount while publishing their research papers (of a single author) in Global Journals Inc., if the same is accepted by our Editorial Board and Peer Reviewers. If you are a main author or co-author of a group of authors, you will get discount of 10%.

As MARSE, you will be given a renowned, secure and free professional email address with 30 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSE member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

Once you are designated as MARSE, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.

Auxiliary Memberships

Institutional Fellow of Open Association of Research Society (USA)-OARS (USA)

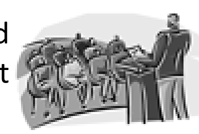
Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).

The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

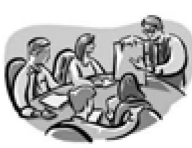
The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.
The author fees of such paper may be waived off up to 40%.



The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

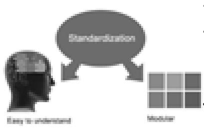


The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.



After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

"

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone. "

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

Copyright

During submission of the manuscript, the author is confirming an exclusive license agreement with Global Journals which gives Global Journals the authority to reproduce, reuse, and republish authors' research. We also believe in flexible copyright terms where copyright may remain with authors/employers/institutions as well. Contact your editor after acceptance to choose your copyright policy. You may follow this form for copyright transfers.

Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Engineering Research Paper

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.
22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.
23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- o Single section and succinct.
- o An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- o Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- o Explain the value (significance) of the study.
- o Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- o Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- o Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

INDEX

save our planet

Global Journal of Researches in Engineering

Visit us on the Web at www.GlobalJournals.org | www.EngineeringResearch.org
or email us at helpdesk@globaljournals.org

ISSN 9755861