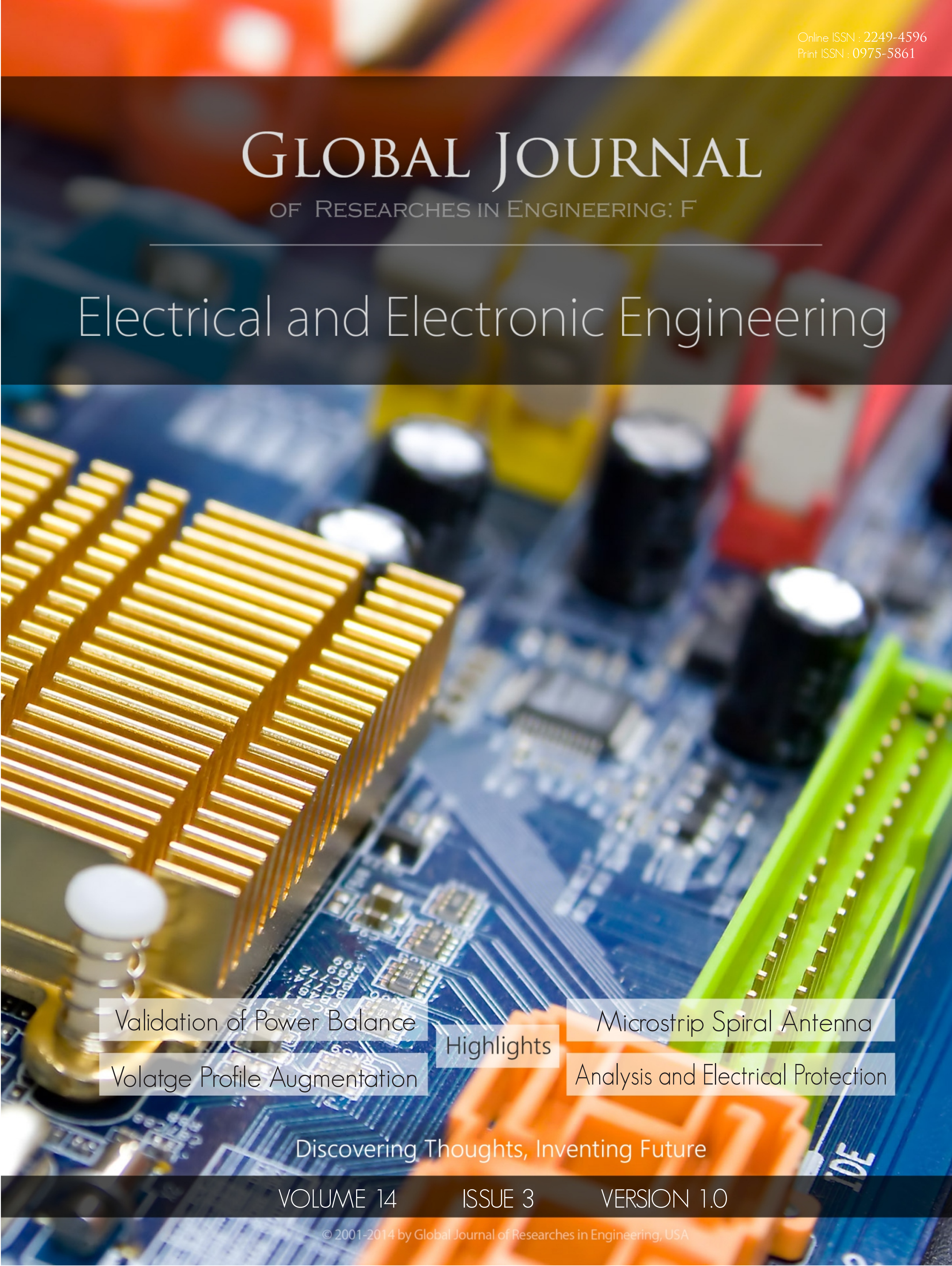
Online ISSN : 2249-4596
Print ISSN : 0975-5861

# Global Journal

## of Researches in Engineering: F

# Electrical and Electronic Engineering



Validation of Power Balance

Volatge Profile Augmentation

Highlights

Microstrip Spiral Antenna

Analysis and Electrical Protection

Discovering Thoughts, Inventing Future

VOLUME 14 ISSUE 3 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 14 Issue 3 (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
301st Edgewater Place Suite, 100 Edgewater Dr.-Pl,
Wakefield MASSACHUSETTS, Pin: 01880,
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
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 (Including by Air Parcel Charges):*

*For Authors:*
22 USD (B/W) & 50 USD (Color)
*Yearly Subscription (Personal & Institutional):*
200 USD (B/W) & 250 USD (Color)

## Integrated Editorial Board
## (Computer Science, Engineering, Medical, Management, Natural Science, Social Science)

# Contents of the Volume

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 14 Issue 3 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

# Design of PID Controller for Direction Control of Robotic Vehicle

By C. S. Mala & S. Ramachandran
*Jawaharlal Nehru Technological University, India*

*Abstract-* A PID Controller has been designed and incorporated into the Robot based Agricultural System. This system comprises of a Robotic Vehicle which navigates through the field in the desired direction performing tilling or de-weeding as it moves. The PID control system has been designed for automatic steering and speed control of the Robotic Vehicle. The PID control system continuously checks and corrects the direction of travel to keep the vehicle on desired track. PID Control equations for Discrete Time Domain have been derived and validated by using MATLAB. Functional tests were carried out using ModelSim. The hardware results were finally validated using MATLAB again. The direction accuracy achieved is better than 0.01%.

*Keywords: PID controller, robot control, agricultural automation, speed control, steering control.*

*GJRE-F Classification : FOR Code: 090699*

DESIGNOFPIDCONTROLLERFORDIRECTIONCONTROLOFROBOTICVEHICLE

*Strictly as per the compliance and regulations of :*

# Design of PID Controller for Direction Control of Robotic Vehicle

C. S. Mala [α] & S. Ramachandran [σ]

*Abstract-* A PID Controller has been designed and incorporated into the Robot based Agricultural System. This system comprises of a Robotic Vehicle which navigates through the field in the desired direction performing tilling or de-weeding as it moves. The PID control system has been designed for automatic steering and speed control of the Robotic Vehicle. The PID control system continuously checks and corrects the direction of travel to keep the vehicle on desired track. PID Control equations for Discrete Time Domain have been derived and validated by using MATLAB. Functional tests were carried out using ModelSim. The hardware results were finally validated using MATLAB again. The direction accuracy achieved is better than 0.01%.

*Keywords: PID controller, robot control, agricultural automation, speed control, steering control.*

## I. Introduction

The Robotic Vehicle is primarily designed to till the field to the specified length and breadth. The movement of the vehicle in any direction be it forward or reverse, should be in a straight line. Otherwise, the vehicle may move haphazardly, not tilling the ground in a straight line. If this operation is carried out manually, the throughput is painfully low. If the entire agricultural operation is carried out using Robotic vehicle, such as the proposed one, which is unmanned, then great care has to be taken to ensure that the movement of the vehicle is in the desired direction always. This calls for an automated feedback system, which keeps track of the wheel direction of the vehicle, compares it with the set direction, and takes corrective measure in case of any deviation from the set direction. There are many techniques reported to achieve the direction control or speed control of the wheels of automatic unmanned vehicles using PID controller.

A tele_operated, farmland information collecting robot [1] was developed using PID Controller and PWM principle [2]. An ideal PID controller is described by Wang Hongxing [3] for a farm land information collecting robot. For tuning of the PID controller parameters, critical proportioning methods are used [4]. A PID Controller developed using 8051 microcontroller [5-6] has been briefly explained with programming done in embedded C.

*Author α: Jawaharlal Nehru Technological University, Hyderabad, India. e-mail: csmala63@yahoo.co.in*
*Author σ: SJB Institute of Technology, Bangalore, India. e-mail: ramachandr@gmail.com*

Suying Yang, Miaomiao Gao, Jianying Lin, and Zhuohan Li have worked on PID controller IP Core for temperature control in System on a Programmable Chip (SOPC). The authors have described the PID Control algorithm using HDL on FPGA [7]. They have designed PID controller IP core to make temperature tests to the control object with features of inertia and pure delay. Avalon bus is used for connecting processor to the peripherals.

Guoshing Huang and Shuocheng Lee have explained the PC based PID speed control in DC Motor [8] using Lab view. It uses Vis Sim software simulator to analyze its response. The signals have been acquired through NI DAQ USB-6008 card. The parameters are adjusted to control the motor speed by using the Lab view aided PID controller.

Zhen Wang and Lingshun Liu [9] have designed a control system using the microcontroller TMS320LF2407A for sampling and regulating the speed of the DC Motor and have used AT89C51 microcontroller for inputting and displaying the speed of the DC Motor.

Junyao Gao et al. [10] have designed control methods for unmanned vehicle. For steering control of the wheels, the authors have applied a complex mathematics using a multistep neural network. Fuzzy Genetic Algorithm (GA) PID control method is used for the turning control of wheels.

An Intelligent Control for a Crawling Unmanned Vehicle [11] have been designed by Dr. Kwang Hwa Lee. An adaptive feedback controller is designed by using a combination of PID and Adaptive Neural network Fuzzy Logic.

Xiaogang Ruan, Qiyuan Wang and Naigong Yu, have designed Dual-loop Adaptive Decoupling Control for Single Wheeled Robot based on Neural PID Controller [12]. They have used Newton-Euler equations in their design to achieve wheel control.

Migara H. et al. have designed a Robotic Arm with Hydraulic actuators operated by servo valves [13]. Each joint position is controlled by a PID based system. The system was modeled using MATLAB-SIMULINK tool box.

M. S. Tsoeu and M. Esmail, have carried out research on Unconstrained Model Predictive Control (MPC) and PID Evaluation for Motion Profile Tracking Applications [14]. The authors have tested optimally tuned Model Predictive Control (MPC) and PID

Global Journal of Researches in Engineering ( F ) Volume XIV Issue III Version I Year 2014

controller for motion profile tracking and have compared them using Pareto optimality. They have found that the results of PID Controller are reasonable, whereas MPC gives unanticipated outcomes.

Xiaogang Ruan, Qiyuan Wang and Naigong Yu have designed Dual-loop Adaptive Decoupling Control for Single Wheeled Robot based on Neural PID Controller [12]. They have used Newton-Euler equations in their design to achieve wheel control.

Migara H. et al. have designed a Robotic Arm with Hydraulic actuators operated by servo valves [13]. Each joint position is controlled by a PID based system. The system was modeled using MATLAB-SIMULINK tool box.

M. S. Tsoeu and M. Esmail have carried out research on Unconstrained Model Predictive Control (MPC) and PID Evaluation for Motion Profile Tracking Applications [14]. The authors have tested optimally tuned Model Predictive Control (MPC) and PID controller for motion profile tracking and have compared them using Pareto optimality. They have found that the results of PID Controller are reasonable, whereas MPC gives unanticipated outcomes.

For tracking stabilization of Robot Motion, a new variable structure PID controller design is considered [15]. A certain PID sliding motion of a controller with PID sliding surface is substantiated for a robotic manipulator. Lyapunov full quadratic form and upper and lower matrix norm inequalities are formulated for sliding and global stability. This control algorithm is applied to robot arm through simulations and the authors have found that the control function is satisfactory.

An approach for a remote PID controller design have been presented by Hui Zhang et al [16]. They have first developed the design method for Static Output Feedback (SOF) Controller, and using this PID controller has been designed. The SOF Controller has been designed using Bernoulli random binary distribution and matrix inequalities.

Chaoraingern J et al. [17] have designed PID Controller using Coefficient Diagram Method (CDM) for track following control of hard disk drive. It is based on proper selection of the characteristic transfer function of the closed loop control system. They have shown through MATLAB simulation results that CDM design is quite stable.

Marino R et al. [18] have designed a nested PID control for lane keeping autonomous vehicles which are vision based. The steering angle is the control input and it is designed taking into account yaw rate and the central offset measured by a gyroscope and vision system respectively. The simulations were carried out on Standard Big Sedan CarSim Vehicle model.

Saidonar M. S. et al. [19] have considered only differential steering control with proportional control methods for a mobile robot. The current velocities of the right and left wheel are used to determine the current position of the mobile robot The velocity and angular velocity of the robot helps to determine the number of encoder pulses that have to be fed to the DC motors connected to the right and left wheel. The proportional controller is used to produce the same speed for both right and left wheel to ensure the movement of the robot in a straight line.

Veerachari Mummadi [20] has proposed a digital PID controller for H bridge soft switching boost Converter. The author has formulated the mathematical models of the H bridge using the system identification tool and has used in the PID design. Designing the PID Controller has been done using Pole Placement Technique (PPT) together with Sensitivity Function Shaping (SFS).

PID Controller has been designed in this work for automatic steering and speed control of the Robotic Vehicle. PID Control equations for Discrete Time Domain are presented and validated by using MATLAB in this section.

The paper is organized as follows. Section 2 presents the PID Controller and Derivation of Discrete Domain PID Controller Equations and MATLAB realization of the same. Section 3 presents the Block Diagram of the Proposed Robotic Vehicle with PID Controller and the Algorithmic state Machine Charts. Section 4 presents the architecture of the PID Controller. Section 5 presents the Simulation results and the Validation of Verilog RTL Design Using MATLAB and Section 6 presents the Conclusion.

## II. PID Control System

The PID controller produces an output signal comprising three terms-one proportional to error signal, another proportional to integral of error signal and the third one proportional to the derivative of error signal. Fig.1 presents the PID controller in its expanded form.

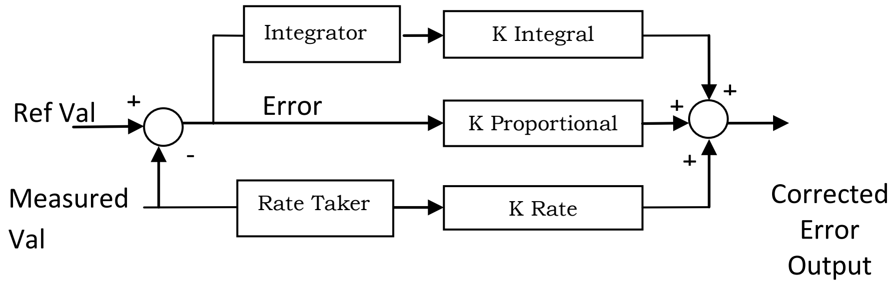



*Figure 1 :* Block Diagram of PID Controller

PID control may be achieved in continuous time domain by computing an error term such as:

$$u(t) = K_p\, e(t) + (K_p/T_i) \int e(t)\, dt + K_p T_d\, (d/dt)\, e(t) \quad (1)$$

or

$$u(t) = K_p\, e(t) + K_i \int e(t)\, dt + K_d\, (d/dt)\, e(t) \quad (2)$$

where,

$u(t)$ = Total Corrected Error,

$K_p$ = Proportional Gain,

$T_i$ = Integral Time,

$T_d$ = Derivative time,

$K_i$ = Integral Gain = $K_p/T_i$ and

$K_d$ = Proportional Gain = $K_p T_d$.

The proportional control stabilizes the gain but produces a steady state error. The integral control reduces or eliminates the steady state error. The derivative control reduces the rate of change of error. For example, in steering control, if the reference or set direction is 180 degrees and if the robot is moving off from the set direction, say, to 182 degrees, then the controller dynamically corrects the wheel speeds in such a manner that the robot moves closer to 180 degrees. The frequency at which the measured direction is input is called the sampling rate. Higher the sampling rate, greater will be the precision in correcting the error. The PID control is also achieved at the same rate.

*a) Derivation of Discrete Domain PID Controller Equations*

Fundamental PID Controller equations were presented in the previous section. In this section, discrete domain equations are so derived that it is amenable for Verilog RTL coding. To start with, the following assumptions are made:

- Number of samples = n,
- Sample rate (say, 25 Hz depending on the sensor employed) = SR,
- Desired direction of the Robot = set_dir, and
- Actual measured direction from a digital compass = dir (n).

The difference between the set and the measured directions naturally is the error expressed as Eq. 3.

$$e(n) = set\_dir - dir(n) \quad (3)$$

Overall Error computed by the Proportional, Integral and Differential terms of the PID Controller may be derived from Eq. (2) and is presented in Eq. (4).

$$u(n) = K0 * e(n) + K1 * e(n-1) + K2 * integral\,(n) \quad (4)$$

where K0, K1 and K2 are constant gain factors for the Proportional, Differential and Integral terms respectively and

$$integral\,(n) = integral\,(n-1) + (set\_dir - dir\,(n))/SR \quad (5)$$

As an approximation, we get the corrected direction:

$$dirn\,(n) = set\_dir + (K2/K0) * integral(n) - u(n)/K0 + [(u(n-1)/K0)/(K2/(K1*SR) + K0/K1)] \quad (6)$$

Equation (6) gives the corrected direction.

In order to get the value of the corrected direction closer to the reference set direction, various values of K0, K1 and K2 were experimented with in the above equation using MATLAB. Optimum values arrived at for these gain constants are presented in the next section.

*b) MATLAB Realization of PID Controller*

The PID Controller equations derived in the previous section has been coded in MATLAB and results of the corrected direction and the set direction for different gain constant values have been presented in Fig. 2 for the Optimum Gain constants. For this set of gain constants, the corrected direction is closest to the set direction with the least overall error. The values for average direction, average error and overall error for different sets of K0, K1, and K2 have also been computed and presented in Table 1.

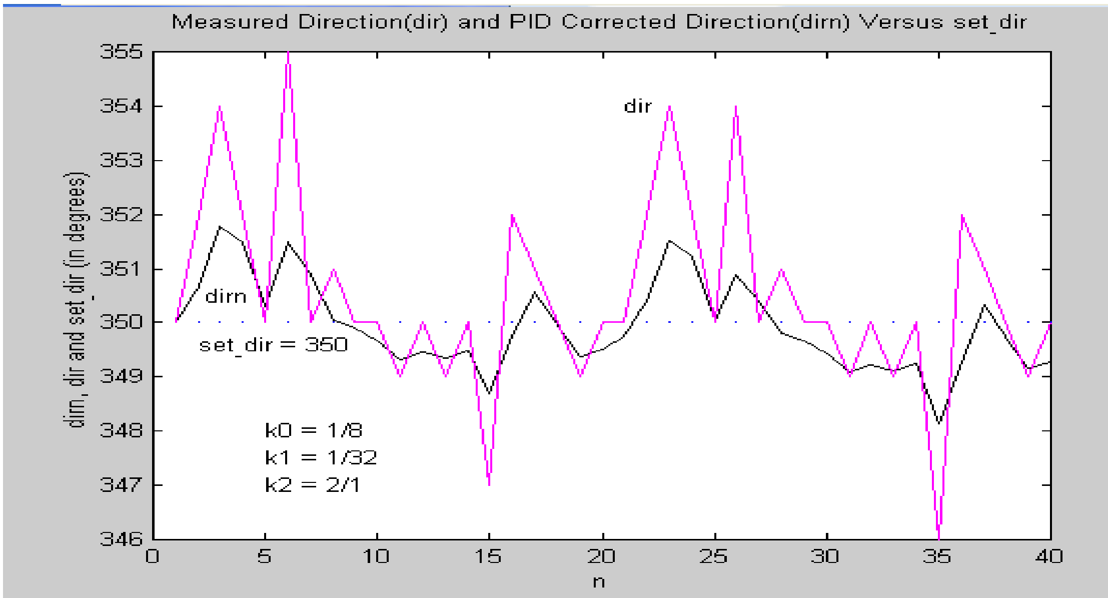



*Figure 2 :* Matlab Results: Comparison of PID Corrected Direction Vs Set Direction for Optimum Gain Constants – Least Error

*Table 1 :* Comparison of Average Error and Overall error for different values of Gain Constants

Set dir = 350 degrees, No. of samples = 40, Sample rate = 25 Hz, Length of Field = 300 ft

| Sl. No. | K0 | K1 | K2 | Avg. Direction | Avg. Error | Overall error in feet |
|---|---|---|---|---|---|---|
| 1 | 1/8 | 1/32 | 2/1 | 350.0024 | -0.0024 | -0.0128 |
| 2 | 1/8 | 0 | 2/1 | 350.1875 | -0.1875 | -0.9817 |
| 3 | 1/8 | 1/32 | 0 | 350.5859 | -0.5859 | -3.0680 |
| 4 | 1/4 | 1/32 | 2/1 | 350.3446 | -0.3446 | -1.8042 |
| 5 | 1/16 | 1/32 | 2/1 | 348.0040 | 1.9960 | 10.4512 |
| 6 | 1/8 | 1/16 | 2/1 | 348.9060 | 1.0940 | 5.7284 |
| 7 | 1/8 | 1/32 | 1/4 | 350.4825 | -0.4825 | -2.5265 |
| 8 | 1/16 | 1/32 | 1/4 | 350.0093 | -0.0093 | -0.0488 |
| 9 | 1/8 | 1/32 | 1/16 | 350.5591 | -0.5591 | -2.9276 |

## III. Block Diagram of the Proposed Robotic Vehicle with PID Controller

The block diagram of PID controller designed for the Robotic Vehicle is presented in Fig. 3. The system comprises the following functional blocks: Digital Compass, PID Controller, Robotic Controller and DC Motor Controller.

A digital compass is used for measuring the earth's magnetic field. It has a built in UART interface and can be readily used with any FPGA, ASIC or Microcontroller based design. The measuring range of the compass is 0 to 360 degrees and it has a resolution of 0.1 degree and an accuracy of 1 degree. The frequency response is 25 Hz. The initial reading is set as is convenient for the field to be tilled. It is the reference direction in which the vehicle is continuously expected to navigate.

The Digital compass output is read every 40 msec. The output is compared with the reference direction. The difference (error) is applied to PID controller for error computation. The error output of the PID controller is input to Pulse Width Generator to produce pulses

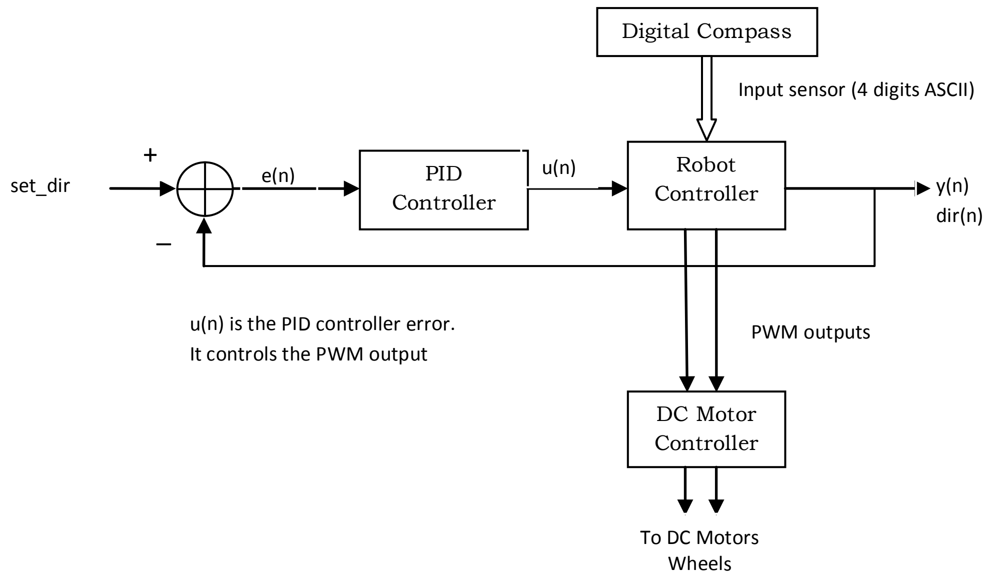



*Figure 3 :* Block Diagram of the Robotic Vehicle with PID Control

proportional to the error computed and is applied to the DC Motor Drivers to correct the error and align the wheels close to the reference direction. The communication with the Digital compass is RS232 based.

The Robotic Controller is responsible for the movement of the vehicle in the set direction. It generates the Pulse Width for the DC Motors that drives the Wheels of the vehicle according to the correction required in the direction of motion. The pulse width generated is fed to the DC motor driver.

*a) Development of Algorithms*

The Robotic Vehicle Controller may be realized by developing Algorithmic State Machine Charts for various blocks. The Digital compass senses the direction of motion and passes on that information serially to the Digital Compass ASCII module of the Robotic Controller. The sensor will begin to send out the measured direction only on receiving the command 31 H on its RX line. The value 31 H is transmitted serially at 9600 baud rate by the Digital Compass ASCII module.

The digital compass starts transmitting the measured value serially on its TX line. The reception baud rate is also 9600. One direction value is received as 7 bytes. The First and second Bytes are 0D H and 0A H respectively. Then the three bytes of data representing the measured direction in ASCII format is received. This is followed by 2E (being Byte 6) indicating decimal point. Byte 7 is the digit after the decimal point. As an example, for 350.0 degrees, the third byte to seventh byte is 33 H, 35 H, and 30 H respectively.

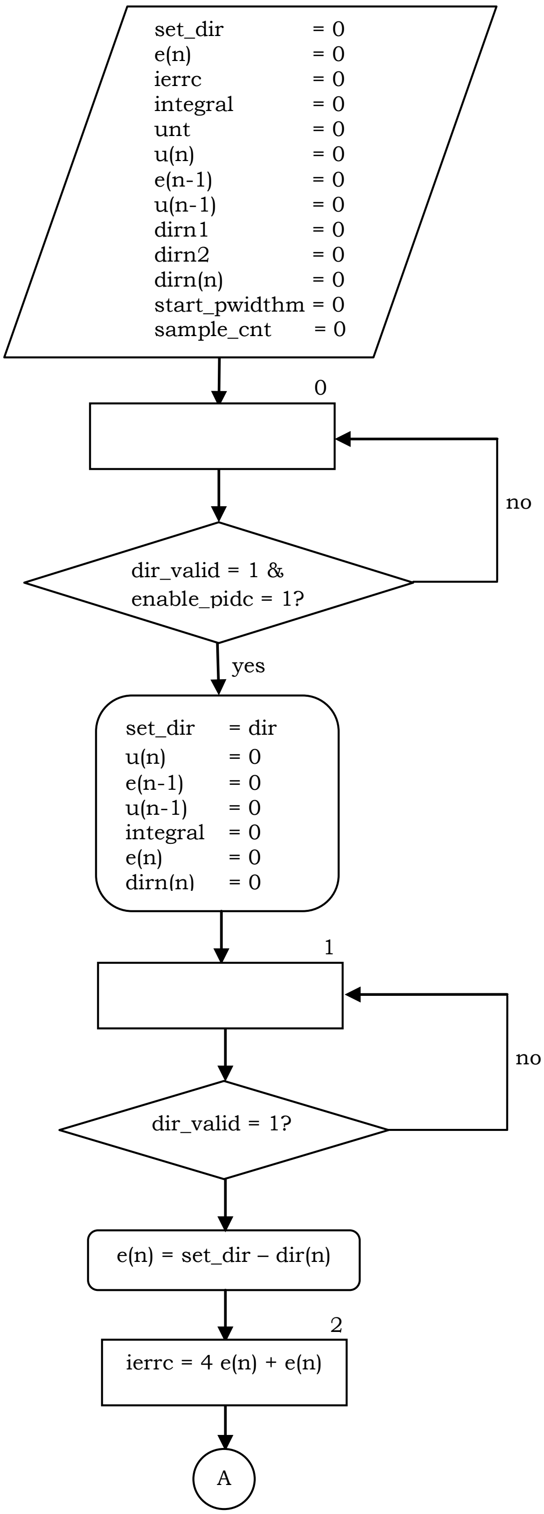
Since the ASM charts for the entire design are numerous, the ASM chart for the PID Controller only is presented as an example in Fig. 4. The main function of this module is to read the current direction of the robotic vehicle, check for deviation from the set direction at 25 Hz sample rate, calculate the error and correct the direction of the vehicle. The vehicle is kept at the desired direction by controlling the pulse width of the right wheels, whereas the pulse width of the left wheel is kept constant.

The PID Controller starts functioning only after receiving a valid "enable_pidc" signal from the main controller. Once the module is enabled, it waits for the direction data output from the Digital Compass module. It acquires the direction data only after getting a valid "data_valid" signal. The first direction data received is treated as the "set_dir" (meaning set direction) for the vehicle. The successive "dir" data received is then compared with the "set_dir" and the corresponding error "e(n)" is computed. Thereafter, the PID corrected error "u(n)" is calculated which is the sum of proportional, integral and the differential errors to compute the corresponding corrected direction "dirn".

Once the corrected direction is calculated, the next task of the PID Controller is to derive the pulse widths for the left and the right wheels. For this purpose, a free running counter "pwidthm" is used, whose terminal count corresponds to 100 % duty cycle. For the left wheels, the counter value is compared with the "set_dir" value, which is equivalent to about 67% duty cycle pulse width and a high pulse output is issued at output pin "pwidthm_l" for the condition: (start_pwidthm = 1) & (pwidthm <= set_dir). Otherwise, Logic "0" is output. Similarly, for the right wheels, a high pulse output is issued at output pin "pwidthm_r" for the condition: (start_pwidthm = 1) & (pwidthm <= dirn).

Otherwise, Logic "0" is output. The output pins "pwidthm_l" and "pwidthm_r" are connected to enable pins of DC Motor Driver IC L298, not presented here.

*Reset Conditions :*



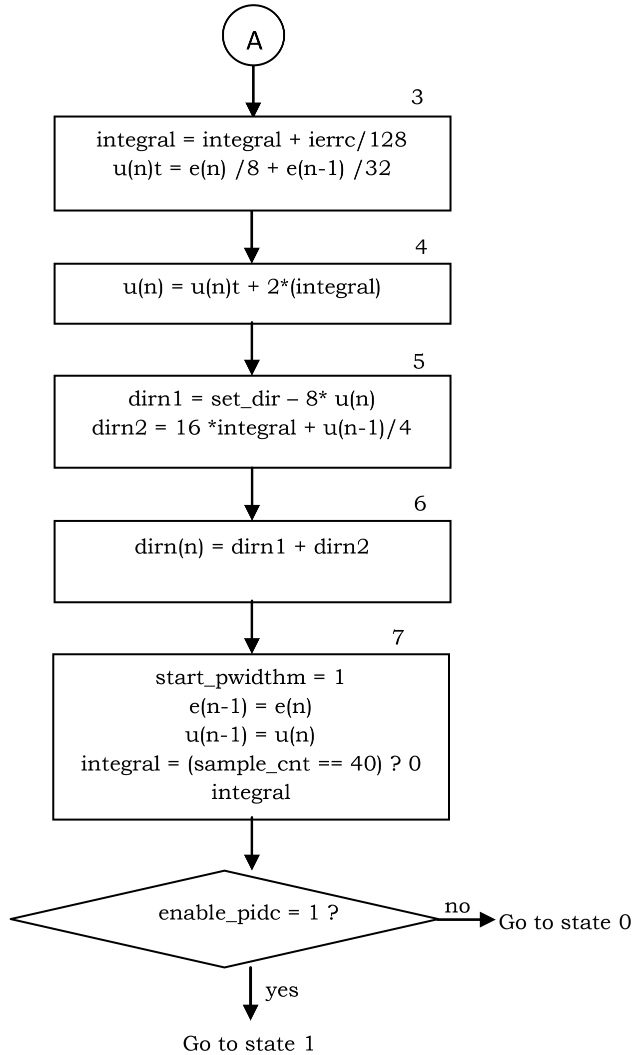




*Figure 4 :* ASM Chart for PID Controller Module

## IV. Architecture of PID Controller

The Architecture of PID Controller comprises the following modules: Digital Compass ASCII, Digital Compass, BCD to Binary conversion and PID controller that have been briefly explained earlier. They are presented in Fig. 5 to Fig. 8.

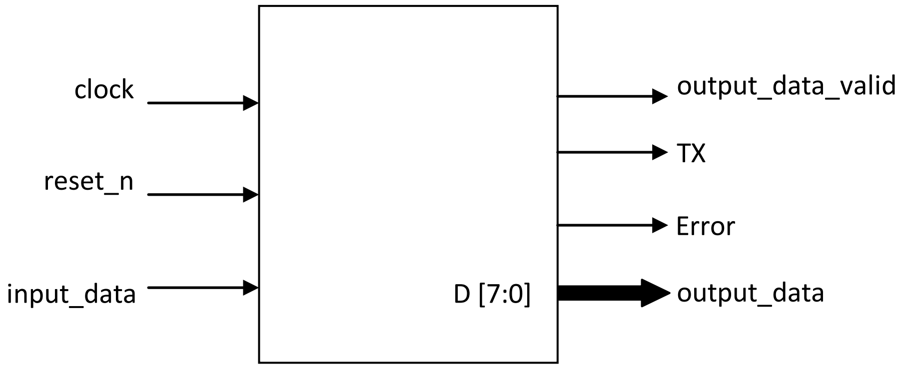



*Figure 5 :* Digital Compass ASCII RTL Module

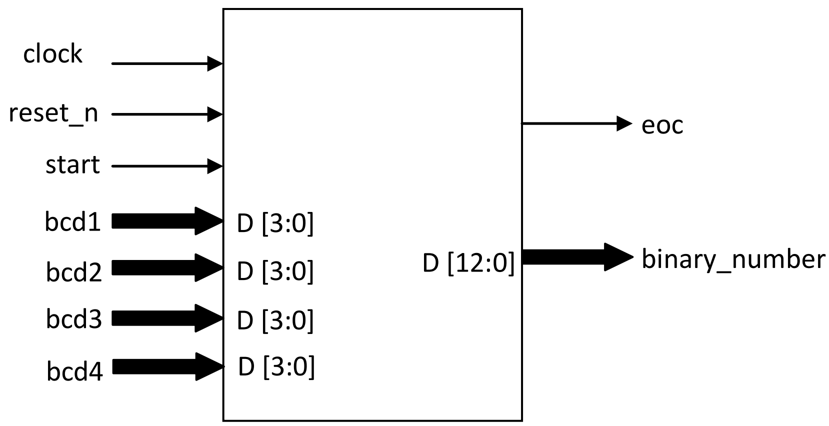



*Figure 6 :* BCD to Binary Converter Module

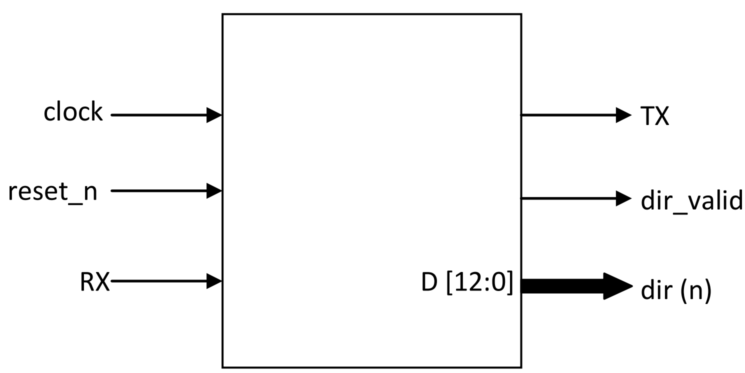



*Figure 7 :* Digital Compass Module

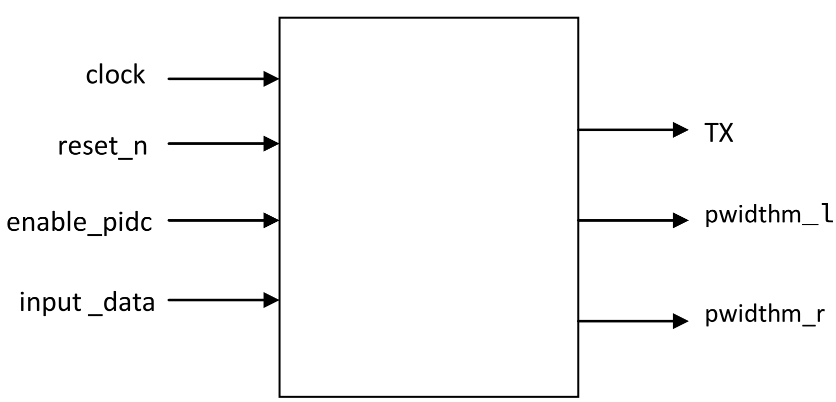



*Figure 8 :* PID Controller Module

## V. Simulation Results

The PID Controller RTL Codes were designed and simulated using Modelsim and tested for several samples of direction data. A test bench was written for the purpose of playing the role of Digital Compass Sensor

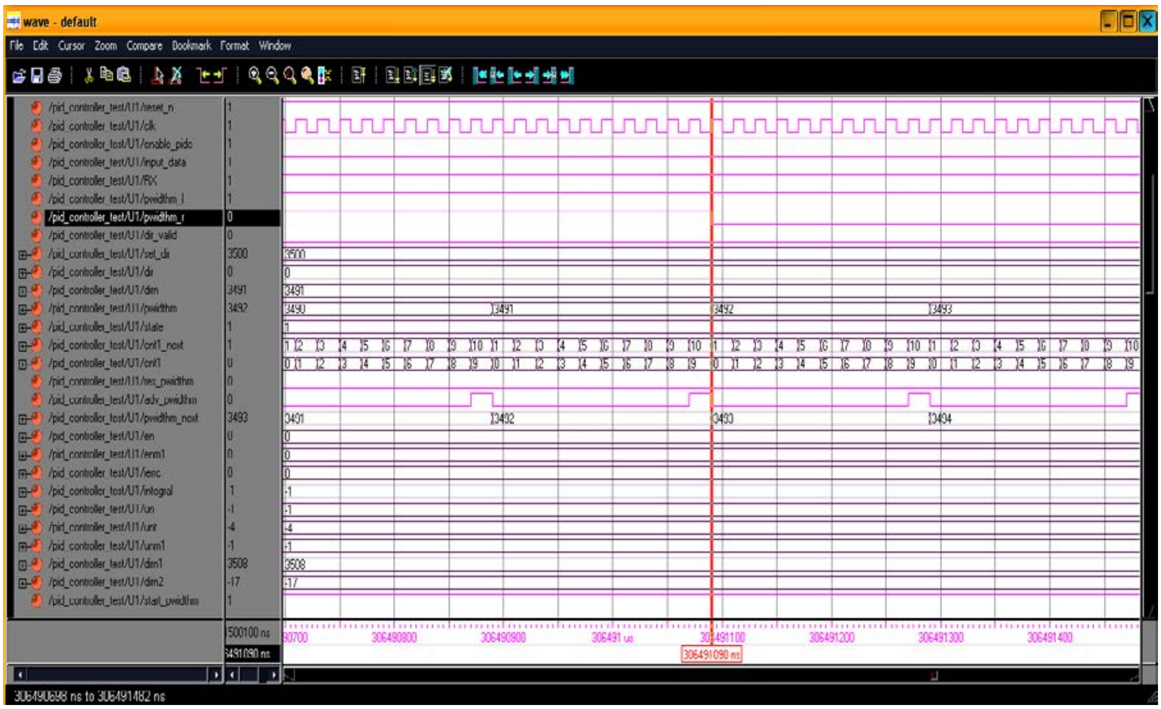



*Figure 9 :* PID Controller Waveform showing Robot Direction Correction

for transmitting the Robot direction and to carry out functional tests. Since the waveforms are too numerous, only the most essential one is presented here. The waveform for the generation of pulse width signals "pwidthm_l" and "pwidthm_r" for left and right wheels are presented in Fig. 9. The signals are generated based on set direction and corrected values of the direction. The generation of the two pulses always starts simultaneously.

The direction is controlled by only the duty cycle of the two pulses. This is achieved by keeping the duty cycle of left wheel constant ("pwidthm_l" low for "pwidthm = 3500") with respect to set direction (set_dir = 3500), whereas the duty cycle of right wheels is determined based on the corrected direction value "dirn". When the set direction and the corrected direction values are equal, the pulse width for all the four wheels is same. In this example, the measured direction "dir" is 350.0. It may be noted that when the current PID computed Robot direction "dirn" matches (3491 meaning 349.1 degrees) the current running counter value "pwidthm", then the right wheels pulse width output "pwidthm_r" is forced low, thus correcting the Robot direction to 349.1 degrees. Although the actual error "e(n)" is zero in this case, the PID computed error "u(n)" is -1. This error is made up in the next sample.

## VI. Validation of Verilog RTL Design using Matlab

Various directions such as the set direction (set_dir), measured direction (dir), PID corrected direction (dirn) and the corresponding pulse width (pwidthm_r) that controls the right wheels of the Robot are plotted using MATLAB for 40 samples of Digital Compass and is presented in Fig. 10. The waveform reveals that the direction correction effected by the RTL code is more effective than even MATLAB in spite of using less precision in Verilog coding, thus validating the Robotic Controller Design.

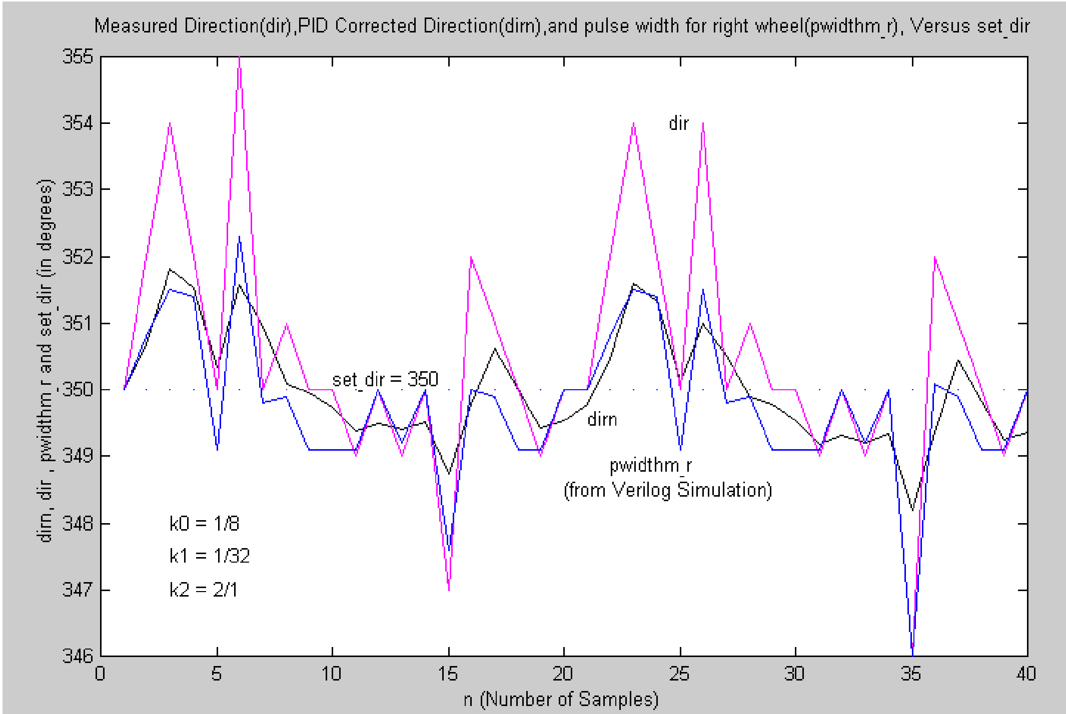



*Figure 10 :* Robot Controller Verilog RTL Design Validation Using Matlab

## VII. Conclusion

A PID Control System for Robot based Agricultural System has been designed. As an example, the set direction is taken to be 350 degrees and the Digital Compass continuously gives out the measured direction at the sample rate of 25 Hz. The number of samples taken is 40 for testing. The PID control system continuously checks and corrects the direction of travel to keep the vehicle on the desired track. PID Control equations for Discrete Time Domain have been derived and coded in Verilog RTL. Functional tests were carried out using ModelSim. The hardware results were finally validated using MATLAB. The direction accuracy achieved is better than 0.01%.

## References Références Referencias

1. Yuzhu Cheng, Yong Chen and Hongxing Wang, Design of PID controller based on Information Collecting Robot in Agricultural Fields, 978-1-4244-9763-8/11, IEEE 2011, pp. 345-348.
2. Blas M. Vinagre, Concepción A. and Monje, Fractional PID Controllers for Industry Application-a Brief Introduction, Journal of Vibration and Control, 2007, Vol. 7, Issue 13, pp. 1419-1429.
3. Zhou Yijun, The Improved critical proportioning method used for self-tuning of PID parameters, Process Automation and Instrumentation, 2002, Vol. 1, Issue 23, pp. 14-16.
4. Wang Hongxing, Research on the Control System of Farmland Information Collecting Robot, NanJing Forestry University, 2008.
5. Hu Na, Development of an information collection robot body in agricultural fields, Nan Jing Forestry University, 2009.
6. Liu Xiaokai, Design and Research of Reactive Control System of DC Motor Based on MCU of C8051F, He Bei University of Technology, 2005, Vol. 12, pp. 72-76.
7. Suying Yang, Miaomiao Gao, Jianying Lin, and Zhuohan Li, The IP Core Design of PID Controller based on SOPC, International Conference on Intelligent Control, IEEE 2010, pp. 363-366.
8. Guoshing Huang and Shuocheng Lee, PC based PID speed control in DC Motor, IEEE, ICALIP 2008, pp. 400-407.
9. Zhen Wang and Lingshun Liu, The design of a speed regulator of DC Motor based on TMS320LF2407A and AT89C51, IEEE 2010.
10. Junyao Gao, Jianguo Zhu, Boyu Wei and Shilin Wang, Unmanned Vehicles Intelligent Control Methods Research, The Ninth International Conference on Electronic Measurement & Instruments ICEMI'2009 Vol3 pp. 736-741.
11. Dr. Kwang Hwa Lee, An Intelligent Control for a Crawling Unmanned Vehicle , MTS 0-933957-28-9, IEEE 2009, pp. 490-499.
12. Xiaogang Ruan, Qiyuan Wang and Naigong, Dual-loop Adaptive Decoupling Control for Single

Wheeled Robot based on Neural PID Controller, 11th Int. Conf. Control, Automation, Robotics and Vision, December 2010 pp. 2349- 2351.
13. Migara H. Liyanage, Nicholas Krouglicof and Raymond Gosine Design and Control of a High Performance Scara Type Robotic Arm with Rotary Hydraulic Actuators, IEEE 2009, pp. 827-832.
14. M. S. Tsoeu and M. Esmail, Unconstrained Model Predictive Control (MPC) and PID Evaluation for Motion Profile Tracking Application, IEEE Africon 13 - 15 September 2011, The Falls Resort and Conference Centre, Livingstone, Zambia.
15. E. M. Jafarov, M. N. A. Parlaksi, and Y. Istefanopulos, A New Variable Structure PId-Controller Design for Robot Manipulators, IEEE transactions on Control Systems Technology, Vol.13, Issue 1, Jan 2005, pp. 122-130.
16. Hui Zhang, Yang Shi and Aryan Saadat Mehr, Robust Stastic Output Feedback Control and Remote PID design for networked motor Systems, IEE transactions on Industrisl Electronics, Vol. 58, Issue 12, Dec 2011, pp. 5396-5405.
17. Chaoraingern J, Ladkrabang, Vaidee W, Trisuwannawat T and Numsomran A, 11th International Conference on Control, Automation and Systems, 2011, pp. 72 – 77.
18. Marino R., Scalzi S., Orlando G, and Netto M, A nested PID steering control for lane keeping in vision autonomous vehicles, American Control Conference 2009, pp. 2885 – 2890.
19. Saidonar M. S., Desa H , and Rudzuan M. N, A differential steering control with proportional controller for an autonomous mobile robot, 7th International Colloquium on Signal Processing and its Applications, 2011, pp. 90-94.
20. Veerachary Mummadi, Design of Robust Digital PID Controller for H-Bridge Soft-Switching Boost Converter, IEEE Transactions on Industrial Electronics, Vol. 58, Issue 7, 2011, pp. 2883-2889.

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 14 Issue 3 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

# Simulator Energy Produced by Photovoltaic Panels used in the Validation of Power Balance in CubeSats

By Francisco C. P. Bizarria, Cleber T. Hoffmann, Geilson Loureiro & José W. P. Bizarria

*Institute of Aeronautics and Space, Brazil*

*Abstract-* The CubeSats are small satellites with cubic shaped structures that are electrically energized only after inserted into orbit operation. Due to this condition it is necessary that the components of the electrical architecture cubesat are properly tested before of the operation in orbit, to highlight the level of reliability suitable for the application in question. In this context, this paper proposes a model to simulate the energy produced by photovoltaic panels in order to make the test charge and discharge batteries that are present in the power distribution system that supplies the electrical and electronic components installed on the cubesat. The validation of the simulation discussed in this work is done by testing the prototype which has been developed for this purpose. The positive results observed in the tests suggest that the simulation is able to reproduce the main conditions of energy production that is performed by the photovoltaic panel's cubesat in the orbit of operation.

*Keywords: simulator photovoltaic panels, energy subsystem, cubesat.*

*GJRE-F Classification : FOR Code: 290901*

SIMULATORENERGYPRODUCEDBYPHOTOVOLTAICPANELSUSEDINTHEVALIDATIONOFPOWERBALANCEINCUBESATS

# Simulator Energy Produced by Photovoltaic Panels used in the Validation of Power Balance in CubeSats

Francisco C. P. Bizarria [α], Cleber T. Hoffmann [σ], Geilson Loureiro [ρ] & José W. P. Bizarria [ω]

*Abstract-* The CubeSats are small satellites with cubic shaped structures that are electrically energized only after inserted into orbit operation. Due to this condition it is necessary that the components of the electrical architecture cubesat are properly tested before of the operation in orbit, to highlight the level of reliability suitable for the application in question. In this context, this paper proposes a model to simulate the energy produced by photovoltaic panels in order to make the test charge and discharge batteries that are present in the power distribution system that supplies the electrical and electronic components installed on the cubesat. The validation of the simulation discussed in this work is done by testing the prototype which has been developed for this purpose. The positive results observed in the tests suggest that the simulation is able to reproduce the main conditions of energy production that is performed by the photovoltaic panel's cubesat in the orbit of operation.

*Keywords: simulator photovoltaic panels, energy subsystem, cubesat.*

## I. Introduction

CubeSats are satellites that adopt physical cubical in shape with typical dimensions of 10 cm edge and maximum mass of 1.33 kg [1]. The interest of cubesat (CS) addressed in this work is to act in an orbit "sun synchronous" with a duration of 96.5 minutes, and the period of 62.73 minutes with the possibility to receive solar radiation, and perform 14 laps around the Earth each day.

Photovoltaic panels for energy generation are installed on all external surfaces of the structure, configured to form a set of four photovoltaic cells connected in series circuit that can provide the level of voltage of 10.79 volts open circuit and capacity generate current under short-circuit of 200.2 mA.

The CubeSats's specifications stipulate that they have to be placed in orbit with its batteries supply power in the "off" state, and these batteries must only be connected to the electrical system when the CubeSats are in their final orbits [1].

Due to this feature being planned for the launch phase and flight of the spacecraft that will carry the cubesat (CS) to orbit operation, it is necessary that the components and / or subsystems installed on cubesat (CS) are tested to evaluate the behavior of electronic and electrical components, and mechanical structure before operation in orbit, in order to prove a reliability level consistent with the application in question.

In this context, this paper proposes a model to simulate the energy produced by photovoltaic panels in order to perform the test charge and discharge batteries that are provided in the distribution system of energy that supplies the electrical and electronic components installed in cubesat (CS).

The validation of the simulation discussed in this article is primarily accomplished through dedicated tests that are applied on a prototype developed for this purpose.

## II. Objectives of the Work

The main goal of this work is to propose a model that can simulate the electricity produced by photovoltaic panels to perform the test charge and discharge batteries that are provided in the power distribution system that supplies the electrical and electronic components installed on cubesat (CS).

Show the first results obtained through simulation of the main conditions of energy production that is performed by the photovoltaic panel's cubesat (CS) operating in orbit.

## III. Architecture Simulation

Figure 1 presents the system components used in the architecture designed to simulate the conditions of production energy that is performed by the photovoltaic panel's cubesat (CS) to orbit operation.

*Author α: Asst. Professor in Electrical Engineering Department-Taubaté University and Systems Engineer in Institute of Aeronautics and Space (IAE), Brazil. e-mail: bizarriafcpb@iae.cta.br*
*Author σ: Master´s in progress in Sciences and Spatial Technologies-Technological Institute of Aeronautics (ITA), Brazil. e-mail: cleber.toss@lit.inpe.br*
*Author ρ: Doctorate at Loughborough University, England, and Systems Engineer in Institute of National Institute of Space Research (INPE), Brazil. e-mail: geilson@lit.inpe.br*
*Author ω: Asst. Professor in Computing Department– Taubaté, University (UNITAU), Brazil. e-mail: jwpbiz@gmail.com*

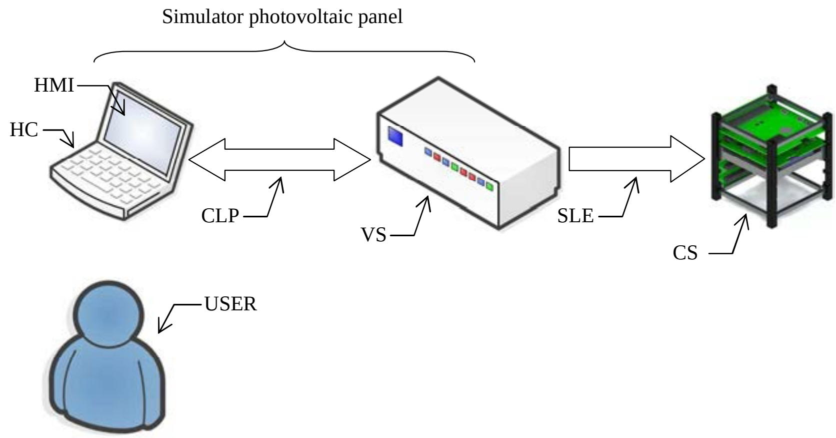



*Figure 1 :* System components

As shown in Figure 1, the simulator photovoltaic panel comprises:

a) The host computer (HC).
b) Communication line with data probabilistic protocol (CLP).
c) Voltage source (VS).
d) Supply line of energy (SLE).

The main function of the host computer (HC) is to hold the human-machine interface (HMI) at the application layer and to perform data communication with the source voltage (VS). To perform the simulation cycle of photovoltaic, the system user (USER) must preliminarily parameterizes the values related to the orbit of the operation cubesat (CS) which will be submitted when operating in the field of windows intended for this purpose.

The line data communication protocol with probability (LCP) is the physical medium that carries the transmission and reception of data between the card data communication computer host (HC) and command port of the voltage source (VS). This line is dedicated and provided with protection against electromagnetic interference.

The voltage source (VS) has means for receiving data and control signals sent by the humanmachine interface (HMI) in order to define a range with specific levels of voltage, which is a function of the characteristics for the supply of electrical current of the cells present in photovoltaic panel's cubesat (CS) [2].

The physical means that established the transport of energy equivalent to the amount generated by the photovoltaic panels for cubesat (CS) is the supply line of electricity (SLE). This line is dimensioned to operate with low Joule losses in the steady state, and with protection against electromagnetic disturbances and over current.

## IV. Computational Model

The computational model was designed to establish a curve relating the voltage and electric current similar to those that are generated by the photovoltaic panels on the operating condition in orbit cubesat (CS). The information contained in this curve are used to carry out remote parameterization of the voltage source (VS) in order to reproduce the characteristics of voltage and current in the supply line of electricity (SLE) of cubesat (CS).

Due to the cubesat (CS) considered in this work has no attitude control, solar panels will be installed on all sides to ensure that at least one face is exposed to solar electromagnetic waves. The maximum conversion of solar energy to electricity happens when the angle between the position of the sun planet and the panel photovoltaic cubesat (CS) is perpendicular. This way it was only considered one face to prepare the model presented in this work.

As shown in Figure 2, the model was developed to simulate the energy generated, with perpendicular incidence on one face of the photovoltaic panel provided for in cubesat (CS) in operating condition in orbit [3].

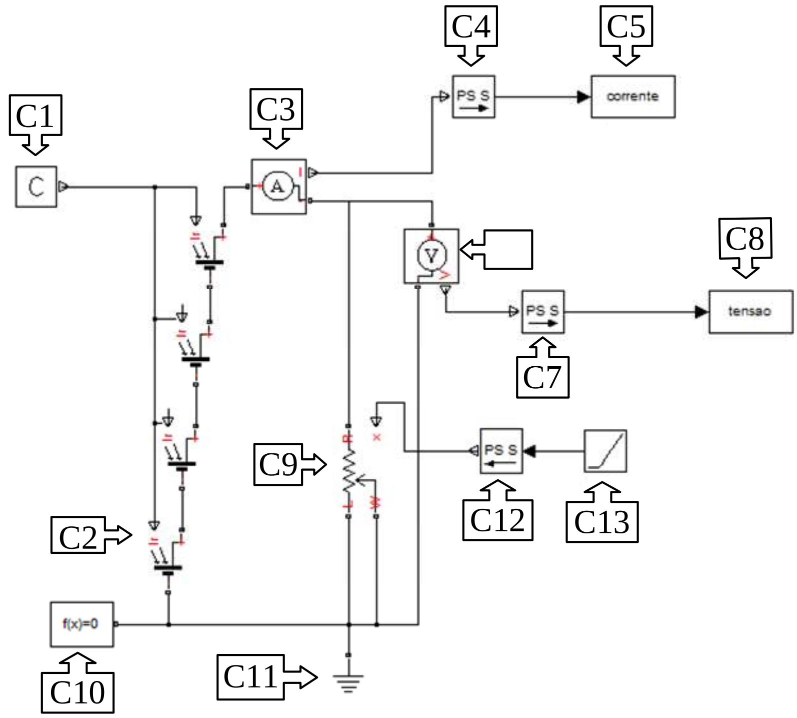



*Figure 2 :* Model for a single face of the solar panel

It can be observed in Figure 2, that the model developed for the electrical characteristics of the set of photovoltaic cells is formed by the following components:

a) C1 - is the perpendicular incidence of electromagnetic waves on the surfaces of solar photovoltaic cells.
b) C2 - photovoltaic cell able to generate electrical current proportional to the area of incidence of electromagnetic waves.
c) C3 - instrument for measuring electrical current with optimal operation.
d) C6 - instrument to measure voltage with optimal operation.
e) C4 and C7 - converters physical signs simulated for the current vectors (C5) and tension (C8), respectively.
f) C9 - variable resistance element.
g) C10 - block parameterization of initial conditions simulation.
h) C11 - reference to the model developed.
i) C12 - converter values assigned by the ramp generator (C13) to make the adjustment of the variable resistance element (C9).
j) C13 - ramp generator with parameterized values.

The value parameterized in the component C1 does not consider losses in the incidence of solar radiation on orbit condition.

The value of the efficiency of the photovoltaic cell is parameterized in the component C2, considered the value of 28% as typical for the study in question [4].

The equivalent current values (C5) and voltage (C8) power generated by the association in series of photovoltaic cells over time is monitored by measuring the voltage (C6) and electric current (C3).

The value assigned to the variable resistance element (C9) is changed over time by the ramp generator (C13) with the goal of obtaining the current vs. voltage curve that is characteristic for the patterned array of photovoltaic cells. The result of the simulation model in question is shown in Figure 3.

The values defined in the curve of Figure 3 are parameterized in the voltage source (VS) to reproduce the condition that electricity generated by the photovoltaic panel's cubesat (CS) in operating condition in orbit.

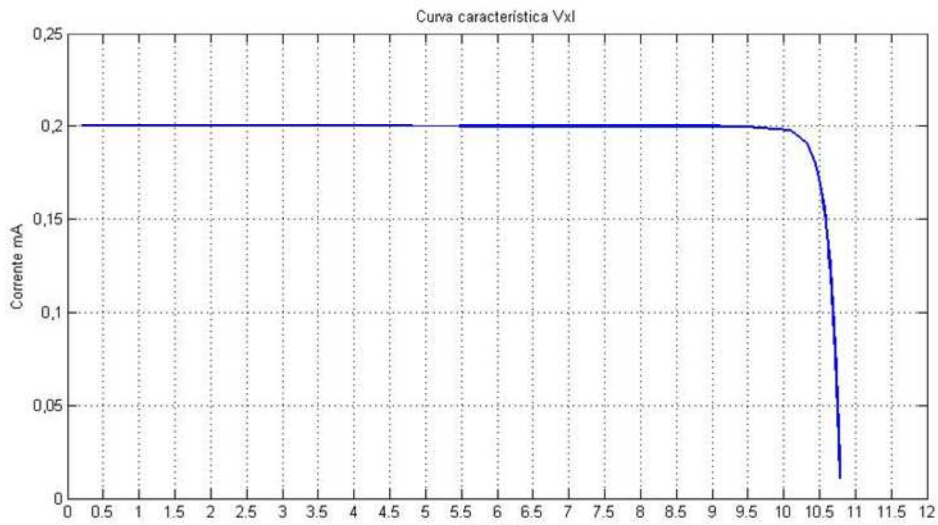



*Figure 3 :* Curve voltage versus current

## V. Prototype

The prototype has been developed to validate the simulations discussed in this work and it is presented in Figure 4.

The set of nomenclatures, components and functions adopted for prototype are the same shown in architecture of the Figure 1.

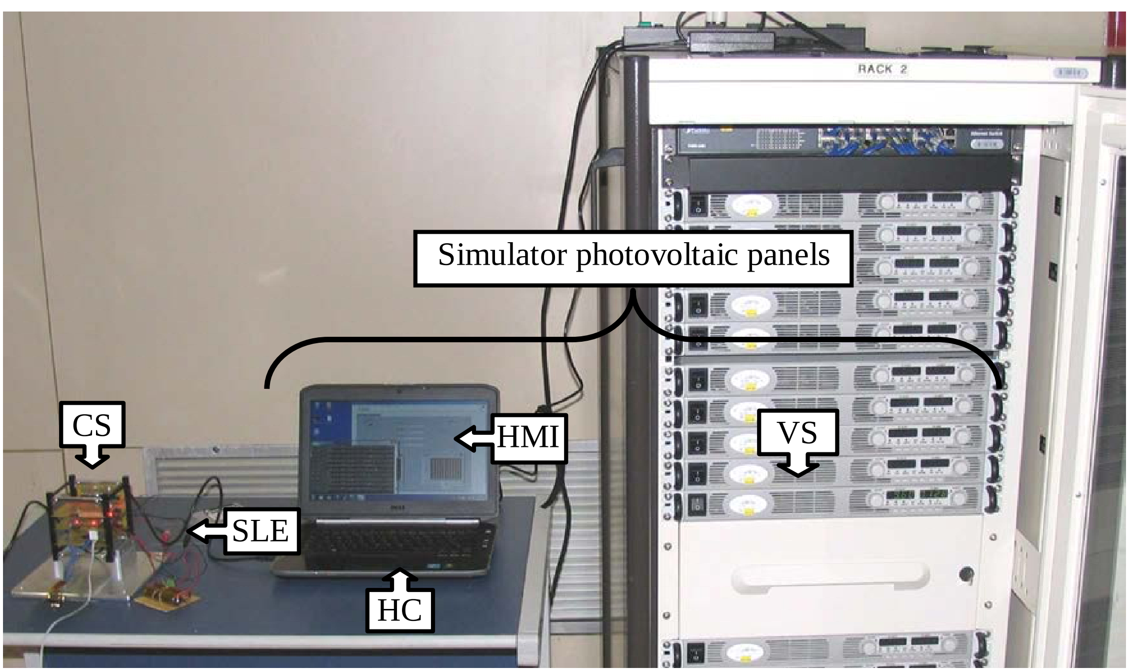



*Figure 4 :* Components of the prototype

The program that manages the simulator operations executes the algorithm that contains the sequence of steps shown in the flowchart of Figure 5.

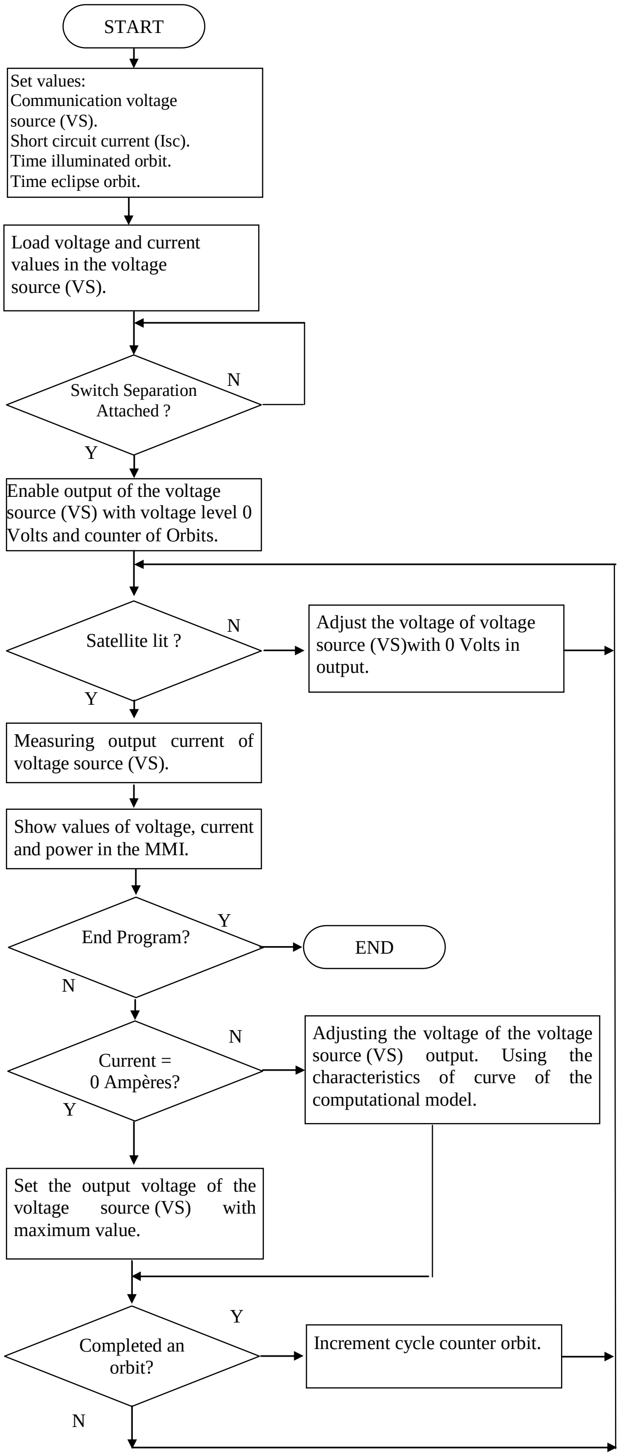



*Figure 5 :* Flow chart management

It is important to emphasize that observing the set of steps contained in the flowchart shown in Figure 5, the value stored in accumulator that performs the orbital cycle count is related to the amount of times that occur charge and discharge cycle that the batteries are subjected in orbit operation. This number of cycles is considered as the main reference in the degradation of battery life.

### *a) Graphic Interface*

Through the graphical interface the system user (USER) parameterizes the values that are required to perform the simulation of the orbit, the command initiation of testing and monitoring of results through remote resources.

Figure 6 presents the window parameterization which was developed with existing resources of an integrated development environment [5], dedicated to this purpose. There are virtual components that allow the system user (USER) command, view and parameterize information related to:

i. P1 (Switch General) - enables the power terminal of the supply line of electricity (LSE).
ii. P2 (enable orbit) - enables time base to playback periods of eclipse, lighted related to orbit operation.
iii. P3 (with VISA) - the communication port of the host computer (VS) that will be used in the transfer of data for the voltage source (VS).
iv. P4 (time Illuminated) - defines the time the cubesat (CS) will receive solar radiation.
v. P5 (time Eclipse) - defines the time the cubesat (CS) will be in the shadow of the Earth.
vi. P6 (Isc) - the value for the maximum short circuit current that will be provided by the array of photovoltaic cells.
vii. P7 (Output Current) - display of the current value of current drawn by cubesat (CS).
viii. P8 (voltage output) - display the current value of the applied voltage electrical system cubesat (CS).

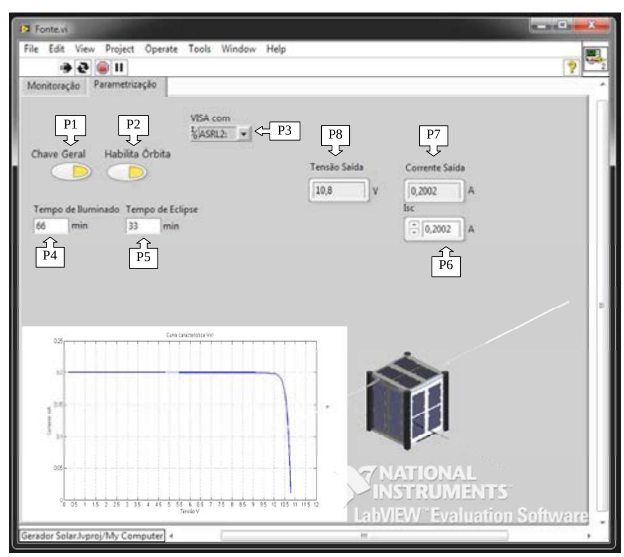



*Figure 6 :* Parameter window

The trend graphs of the voltage and current applied to the electric system of the cubesat (CS), during the time of testing are presented by virtual components contained in the monitoring window, which is shown in Figure 7.

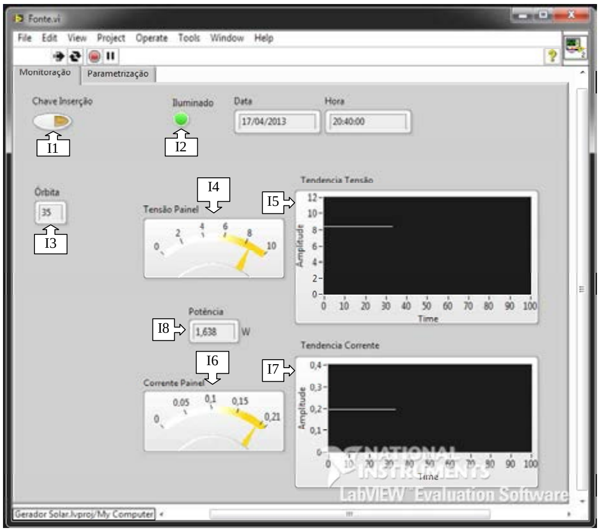



*Figure 7 :* Monitoring window

Virtual components contained in Figure 7 allows the system user (USER) command and monitor the following information fields:

i. I1 (Switch Separation) - controls the time that the cubesat (CS) is inserted into final orbit operation.
ii. I2 (Illuminated) - display indicating the period cubesat (CS) receives solar radiation.
iii. I3 (Orbit) - display the number of cycles orbits performed.
iv. I4 (Voltage Panel) - display, with instantaneous value, the module voltage provided by the array of photovoltaic cells.
v. I5 (Trend voltage) - chart with information levels of voltage provided by the array of photovoltaic cells over time test.
vi. I6 (Power Panel) – display, with the instantaneous value, the module of the electric current supplied by the array of photovoltaic cells.
vii. I7 (current Trend) - chart with information levels of electrical current supplied by the array of photovoltaic cells over time test.
viii. I8 (Power) - display the current value of the active power consumed by cubesat (CS).
ix. Viewers (date, time) indicating the date and time of the host computer (HC).

*b) Operational Tests*

The validation of the components contained in the windows of graphical interfaces was made adopting the following structure:

i. Set the voltage source (VS) to communicate with human-machine interface (HMI) that is installed on the host computer (CH).
ii. A program was developed to perform the steps contained in the analytical flowchart shown in Figure 5.
iii. The layout of virtual components contained in the windows of the graphical interfaces shown in Figure 6 and Figure 7 was adopted.

The tests were performed evaluating all the graphics contained in the windows of graphical interfaces for various times. In this context, the phase parameter is the preliminary condition necessary to perform the activation key insertion (I1) within the window that enables the simulation of the operation of the photovoltaic panel cubesat (CS) in orbit operation.

The prototype made correct simulations of batteries cubesat (CS) charging and discharging in accordance with the program management simulator that performs the steps contained in the analytical flowchart shown in Figure 5.

## VI. Conclusion

The positive results observed in tests performed with the prototype suggest that the method used to simulate the operation of the photovoltaic panel is suitable for reproducing the operating conditions of the orbiting cubesat (CS).

The goals established in this study were affected, mainly in what is related to model development and implementation of computer simulation to determine the electrical characteristics of operation of photovoltaic cells, and thus determine the voltage curve versus electric current that is required to validate the mentioned model.

The strategy used in this work to determine the curve of voltage versus current electrical and subsequently perform validation through prototype testing is consistent to reproduce the characteristics of photovoltaic cells that are installed in panels that convert solar energy to electricity in CubeSats.

## VII. Acknowledgement

This work was developed with the equipment of the Laboratory Testing and Integration (LIT) belonging to the Institute of National Institute of Space Research (INPE).

## References Références Referencias

1. Lee, S. and Munakata, R. Cubesat Design Specification. Rev.12, 2009. Available: <http://www.cubesat.org/images/developers/cds_rev12.pdf>. Date of access:11/03/2013.
2. Agilent Technologies. Agilent E364XA Single Output DC Power Supplies - User's Guide. Rev.8. 2012. Available:<http://cp.literature.agilent.com/litweb/pdf/E3640-90001.pdf>. Date of access:16/05/2013.
3. Math Works, Inc. Start the simulink Software. 2012. Available:<www.mathworks.com/help/simulink/gs/star-ting-simulink-software.html>. Date of access: 13/12/2012.

4. Morales, R. Performance of advanced triplejunction solar cells. Santiago del Chile, Diplomová práce. Pontificia Universidad Catolica del Chile, 2005.
5. National Instruments Corporation. LabVIEWTM - Getting Started with LabVIEW. 2012. Available: <http://www.ni.com/pdf/manuals/373427h.pdf>. Date of access: 30/01/2013.

This page is intentionally left blank

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 14 Issue 3 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

# Rail Parameters Monitoring for the Fire Safety System in the Compartments using Automation Technology

By S. Ramesh
*SRM University, India*

*Abstract-* Today in the real time world, transport plays the major role in the human's life. The transport may be air, train, road, either by any one of the following ways. But according to our survey analysis for long distance communication people prefer rail transport when compared to air and road. The reason for that because rail transport is sophicated way to travel. So all kinds of people prefer rail transport only. So for those people we have to give the safety journey. Now-a-days the accidents are occurs in the railways perioadically. The accidents means it can occurs in detection, collision, bomb disaster and fire in the compartments. Out of all the parameters we are going to discuss about fire safety system alone. Fire safety system (FSS) can be implemented through automation techniques. The parameters and analysis is allowed for only Indian railway networks alone.

*Keywords: alarm, automation techniques, ECU, fire alert system, LED, zigbee WSN.*

*GJRE-F Classification : FOR Code: 290903*

RAILPARAMETERSMONITORINGFORTHEFIRESAFETYSYSTEMINTHECOMPARTMENTSUSINGAUTOMATIONTECHNOLOGY

# Rail Parameters Monitoring for the Fire Safety System in the Compartments using Automation Technology

S. Ramesh

*Abstract-* Today in the real time world, transport plays the major role in the human's life. The transport may be air, train, road, either by any one of the following ways. But according to our survey analysis for long distance communication people prefer rail transport when compared to air and road. The reason for that because rail transport is sophicated way to travel. So all kinds of people prefer rail transport only. So for those people we have to give the safety journey. Now-a-days the accidents are occurs in the railways perioadically. The accidents means it can occurs in detection, collision, bomb disaster and fire in the compartments. Out of all the parameters we are going to discuss about fire safety system alone. Fire safety system (FSS) can be implemented through automation techniques. The parameters and analysis is allowed for only Indian railway networks alone.

*Keyterms: alarm, automation techniques, ECU, fire alert system, LED, zigbee WSN.*

## I. Introduction

Travel is fascinating, of these train travel is comfortable. With the increased comfort level in train transport and traffic in rails we are in an extremely important situation to improve the safety concerns in train travel. This paper explains the safety measurements in compartments for the passengers to travel. Indian Railways is quite unique and distinctive in character, really a microcosm of India. To make it a safe and reliable system is an enormous challenge. The Railways has the most intricate and involved inter-dependencies. A single flaw in the 64,600 route kms of track that criss-cross the country, a defect in over 9,500 locos, 55,000 coaches and 2.39 lakh wagons that haul about 23 million passengers and nearly 2.7 million tonnes of freight every day, an incorrect indication on one of the thousands of signals that dot the rail landscape, a mistake or an act of negligence by one of its staff directly associated with train running, even a rash act by one of the millions of road users who daily negotiate around odd level crossing gates spread across the system, an irresponsible act of carrying inflammable goods–any one of these multiple possibilities has the potential to cause a major tragedy. Added to these are the acts of sabotage by misguided elements spanning the whole country. Thus utmost vigil is safety in operations and also security of the traveling public is accorded by the Railways. Despite a number of safety drives carried out by railways, fire accidents continue to take place, raising serious questions over the effectiveness of the national transporter's preparedness. There were 10 major fire incidents on trains since 2012 which claimed 65 lives besides causing a damage to the railways to the tune of around Rs 8 crore. Realising the seriousness of the situation, the railways is now planning to introduce an Australian technology to make fire alarms efficient. On 30 June, 2012, 35 passengers were killed and 25 others injured when a coach of the Delhi-Chennai Tamil Nadu Express caught fire near Nellore in Andhra Pradesh Though railways claim to have taken various measures to prevent fire in trains, recurrence of such mishaps on regular basis is a matter of concern for the government This paper also explains the possible future in automation compartments system in global scale. These system design is very cost worth system and on implementation can yield better results. India leading in the train compartments all over the world and with its varsity wills the best place to implement the system. This system comes in challenging models with TAS.

*Author: SRM University, Shalimar Garden, Ghaziabad, India.*
*e-mail: ramembengineer@gmail.com*

## II. Train– Fire Accidents

The term "accident" envelopes a wide spectrum of occurrences with or without significant impact on the system. Consequential train fire accidents include mishaps with serious repercussion in terms of loss of human life or injury, damage to railway property or interruption to rail traffic in excess of laid down threshold levels and values. These consequential train accidents include collisions, derailments, fire in trains, road vehicles colliding with trains at level crossings, and certain specified types of "miscellaneous" train mishaps. Why we have taken this survey there are lot of fire accidents happens in train continuously. So in this proposed paper we are going to give the basic idea to avoid the fire accidents. Here the Table showing the trend of train Fire accidents on Indian Railways since 1960-61 is as follows:

Global Journal of Researches in Engineering ( F ) Volume XIV Issue III Version I Year 2014

*Table 1 :* Train Fire Accidents on Indian Railways since 1960-61

| Year | Fire in trains |
|---|---|
| 1960-61 | 405 |
| 1961-62 | 236 |
| 1962-63 | 55 |
| 1963-64 | 81 |
| 1964-65 | 31 |
| 1965-66 | 42 |
| 1966-67 | 50 |
| 1967-68 | 42 |
| 1968-69 | 48 |
| 1969-70 | 47 |
| 1970-71 | 12 |
| 1971-72 | 22 |
| 1972-73 | 25 |
| 1973-74 | 13 |
| 1974-75 | 23 |
| 1975-76 | 27 |
| 1976-77 | 16 |
| 1977-78 | 14 |
| 1978-79 | 12 |
| 1979-80 | 21 |
| 1980-81 | 29 |
| 1981-82 | 23 |
| 1982-83 | 20 |
| 1983-84 | 17 |
| 1984-85 | 30 |
| 1985-86 | 21 |
| 1986-87 | 13 |
| 1987-88 | 12 |
| 1988-89 | 3 |
| 1989-90 | 8 |
| 1990-91 | 9 |
| 1991-92 | 9 |
| 1992-93 | 9 |
| 1993-94 | 3 |
| 1994-95 | 5 |
| 1995-96 | 5 |
| 1996-97 | 4 |
| 1997-98 | 6 |
| 1998-99 | 6 |
| 1999-2000 | 21 |
| 2000-01 | 17 |
| 2001-02 | 9 |
| 2002-03 | 14 |
| 2003-04 | 14 |
| 2004-05 | 10 |
| 2005-06 | 15 |
| 2006-07 | 4 |
| 2007-08 | 5 |
| 2008-09 | 3 |
| 2009-10 | 2 |
| 2010-11 | 2 |
| 2011-12 | 4 |
| 2012-13 (upto January 2013 Prov.) | 8 |

Fire on a running train is more catastrophic than on a stationary one, since fanning by winds helps spread the fire to other coaches. Moreover, passengers sometime jump out of a running train on fire resulting in increased casualties. In case of fire in running train, every railway staff available on the train or at the site shall immediately try and stop the train and plunge into action to save lives and property.

*a) Following Sources are main causes of fire in trains*

- Carrying stoves, sigris, gas cylinders, kerosene oil, petrol, fire works etc. in passenger compartments.
- Lighted match sticks, cigarette ends carelessly thrown.
- Short circuit in electrical wirings.

All railway staff and passengers should take all possible precautions to avoid any of the above mistakes so that possibility of fire breaking out can be minimized. In general fire originates in a small level. When it is surrounded by burning materials with adequate supply of air, fire spreads.

*b) Action to be Taken in case of fire in Train*

- First and foremost immediately summon the fire brigade.
- Secondly, if you smell gas or vapour, or even in case of excessive smoke, hold a wet cloth loosely over your nose & mouth and breath through it in as normal a manner as possible.

## III. Literature Review

*a) Existing Methods*

i. *Measures to reduce incidents of fire in trains:*

IR have always endeavoured to enhance fire worthiness of coaches by using more fire retardant furnishing materials such as Compreg Board/PVC for coach flooring, laminated sheets for roof, ceiling wall & partition panelling, rexene and cushioning material for seats and berths, FRP windows and UIC vestibules etc. Specifications for such furnishing materials have been periodically upgraded to incorporate the fire retardant parameters in line with UIC/other international norms. All new manufacture of coaches/periodical overhauling of existing coaches is being carried out with fire retardant specifications of the furnishing materials. With a view to improve fire safety in running trains, a pilot project for provision of Comprehensive Fire and Smoke Detection System has been taken up in one rake of Rajdhani Express on East Coast Railway. Similar automatic fire alarm system in 20 more rakes for extended field trials has also been decided. Guard-cum-Brake Van, AC coaches and Pantry Cars in all trains are provided with portable fire extinguishers to cater for emergencies due to fire accidents. Improved materials for electrical fittings and fixtures such as MCB, light fittings, terminal boards, connectors, etc., are being used progressively. Detailed instructions have been issued to Zonal Railways for observance of safe practices in handling of pantry cars and for ensuring periodical inspection of electrical and LPG fittings in the pantry cars. Intensive publicity campaigns to prevent the travelling public from carrying inflammable goods are regularly undertaken. Measures have also been taken to prevent fire due to electrical short circuits in coaches, which include three levels of protection in non AC coaches in case of short circuits. Failure of 1st level fuse protection will cause fuse at 2nd level and 3rd level to protect the coach from short circuit. To enhance electrical safety of coaches, only halogen free, fire retardant, low smoke e-beam irradiated cable is being provided in new coaches. Two separate Fire Safety Audit Teams have been constituted recently to plan fire safety audits.

*b) Proposed System*

The proposed system implements the Fire Safety system (FSS) using automation techniques. In this techniques the train engine wants to be fully automated, so we can called (ATE) Automated train engine. In this concept ATE is fully automated and connected to all the coaches from engine. In all the compartments we want to fix the temperature sensor and alarm, whenever the temperature exceeds in the coaches the temperature sensor will sense and it will send the message to the engine through zigbee. At the same time (ECU) Engine control unit is fixed with Alarm & LED. So the signal will be received from coaches, the alarm will blinks and at the simultaneously time the LED will shows which compartment is having the fire. Here in this scenario we have to take two conditions because in all trains we are having two types of coaches AC & Non AC.So we will fix the temperature sensor based on the coaches. At the same time we want to fix the alarm in all coaches to give alert to all passengers.

## IV. Hardware Module

*a) Zigbee WSN*

The sensor is a basic unit and platform of the wireless sensor network. A sensor is commonly composed of a sensor module, a processing module, a ZigBee wireless module and a driver display module. The sensor module is responsible for wave Avoidance of Fire Accident on Running Train Using ZigBee Wireless Sensor 585 electrical conversion and collecting parameters such as relative humidity and atmospheric temperature. This module processing is used to calculate the temperature, sensing alarm node and sending the signal to engine driver. The ZigBee wireless module is responsible for receiving a reliable signal and it illuminates the warning light indicating to stop the train by engine driver. The LED display module monitors the coaches and prevents the fire accidents by using Temperature sensor. In this Sensor, it calculates the increased temperature over the atmospheric temperature and then it transmits the signal to the engine driver through ZigBee wireless technology. Simultaneously alert the passenger by alarm.

*b) IR Temperature sensor*

Temperature sensor been common place in a variety of automotive applications, enabling the enhancements of automotive systems. The ongoing trends to improve the systems performance and efficiencies, the driver convenience and reduction of emissions to drive new temperature sensor applications. The paper will discuss the IR temperature sensors how to protect the fire compartments in the rails. The IR temperature sensor is used to measure the temperature of the train coaches. The readings from this sensor are then fed back to the Engine control unit (ECU). This data from the sensor is then used to find out the temperatures position of the Coaches through LED.

*c) LED*

The led used here is to know for the coach temperature position. If temperature is increasing in some coaches it will shows in the LED display.

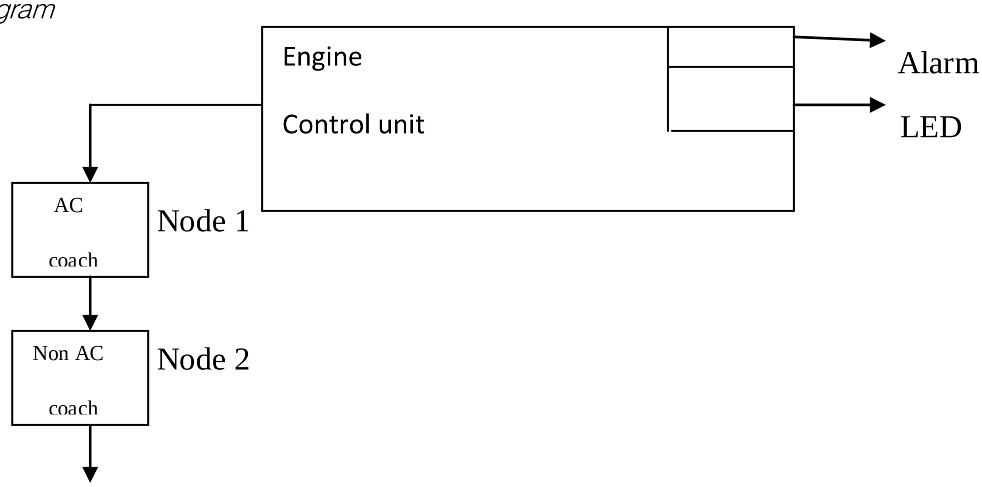
*d) High Alarm Detection*

Here we are using high detection to find the fire accidents; due to some malfunctions in the coaches the alarm will blinks and the engine driver will stop the train. At the same time alarm fixed in the coaches it will give alert to the passengers.

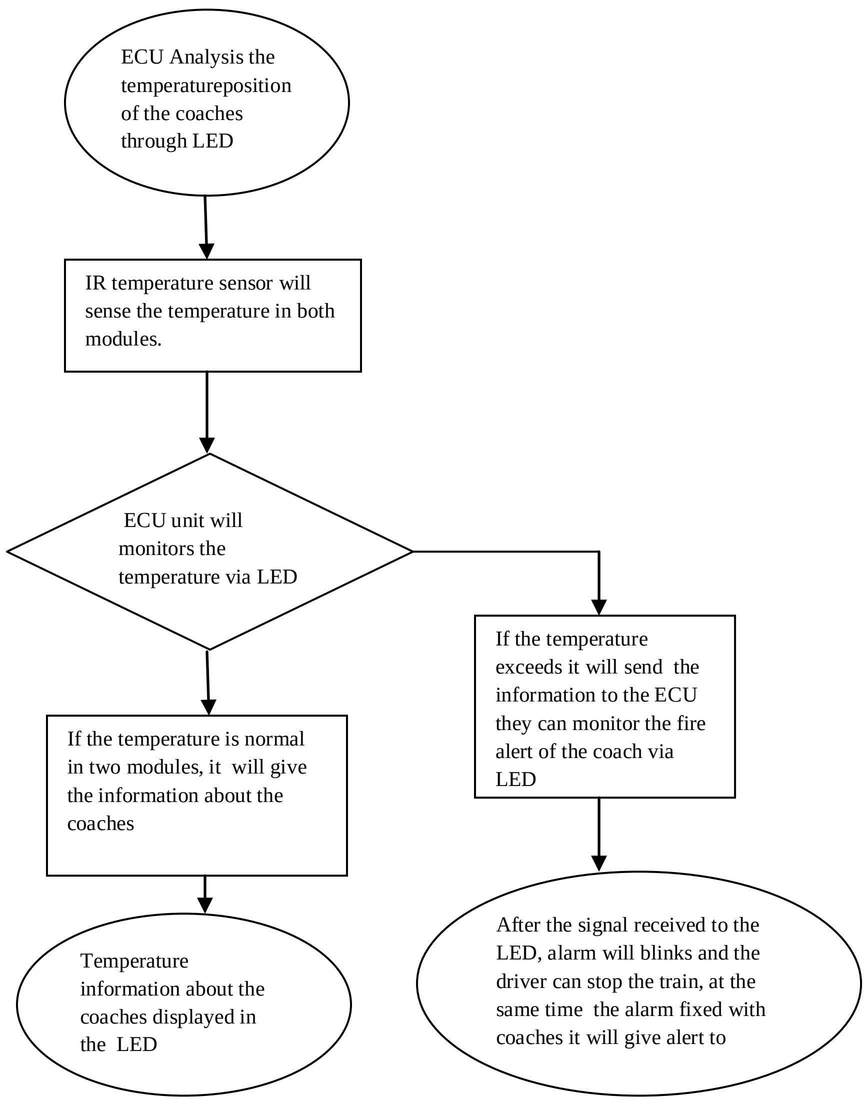
## V. Nature of Work

Here our work is to design the coaches with IR temperature sensor and alarm in the coaches. In trains all coaches want to be fixed with the IR temp sensor. Before we are going to fix the IR temperature sensor we have to fix the sensor in two modules. One module for AC coaches and other for the Non AC Coaches. The IR temperature sensor is fixed in all coaches, all sensor are interconnected in the serial row with WSN and it will send the message to the ECU through Zigbee communication. All sensor in the coaches connected to the node 1 and node 2, and the nodes are connected with the gateway sensory node and then to the Engine control unit. If the Temperature will exceeds in the both modules, the temperature sensor will sense and it will send the signal to the ECU, at the same time ECU is fixed with Alarm and LED. So once the signal gets received the alarm will blink in engine and in coaches also. Now with the help of alarm the driver can stop the train and they monitor the coaches with LED which coach is having fire alert. Here in this scenario the condition will differ for two modules. Because the AC & Non AC coaches having different temperature. The alarm already fitted in the coaches it will give alert to the passengers.

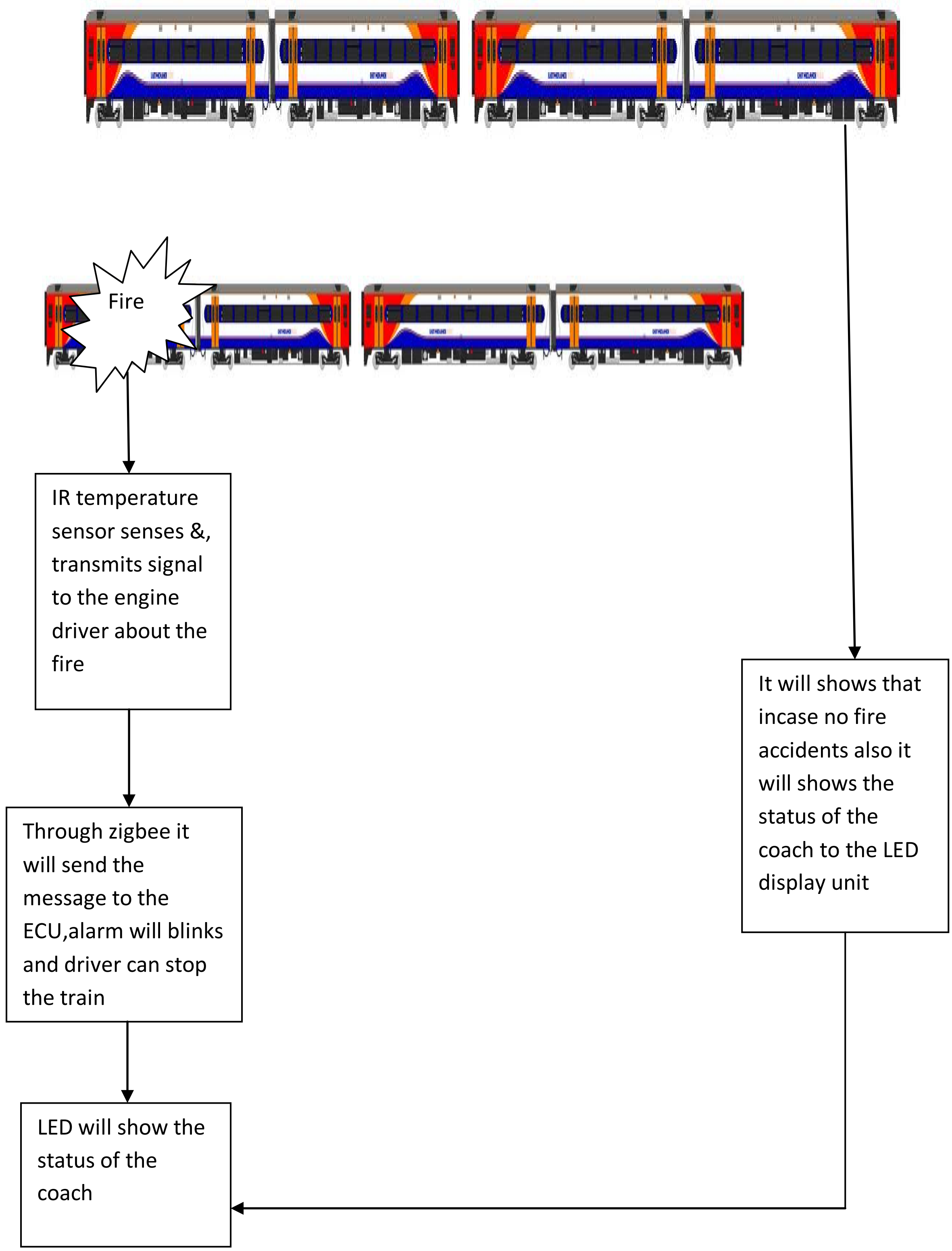
- *Block Diagram*




- *Flow Chart Design*



- *Overall View Process*



## VI. Conclusion

Safety has come to be recognized as the key issue for the railways and one of its special attributes. No railway system can survive by ignoring this vital aspect as safe and timely transit is not only significant for passenger traffic but also for transportation of materials, in today‟s highly competitive environment. In recent years, safety of railways is becoming over arching concern in major countries like USA, England, Australia and those governed by the European Commission. In the working of railways system in these countries, the trend is to statutorily ensure that safety is accorded highest priority. Thus, the above scenario presents a strong case for immediate steps to bolster safety orientation of Indian Railways along with inculcating a culture of zero tolerance of accidents. The constant Endeavour of the Indian Railways is to become the leader in the nation‟s transportation sector by providing modern, reliable, safe, customer-led and customer-focused services to the nation. Safety is an ethos that should pervade all activities of railway operations and maintenance. There are lot of train accidents happens like Detection, collision, derailment, fire. Here we can take the analysis for fire safety system and the proposed model also discussed. The survey taken from Indian railway networks alone and solution also discussed for this only. To reduce the fire accidents this methods will definitely applicable. Once we tried this design in real time it will helpful for railway to reduce the fire accidents in the coaches at the same time we can assure that it will save the fire accidents.

## References Références Referencias


1. www.interrailsafety.com/perth/press/sharma-paper.pdf 45 *op.cit.*, High Level Safety Review Committee 2012, p. 93.
2. www.indianrailways.gov.in (Corporate Safety Plan)
3. http://www.ncr.indianrailways.gov.in/view_section.jsp?lang=0&id=0,7,385,386,782
4. http://en.wikipedia.org/wiki/Wireless_sensor_network
5. http://www.firstpost.com/india/indian-railways-to-introduce-australian-technology-to-fight-train-fires-1329535.html?utm_source=ref_article

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 14 Issue 3 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

# Study of the Power Consumption of a Digital-Front-End using Random Sampling

By M. Diop, Deng Xiaoyu & J.-F. Diouris
*Université Cheikh Anta DIOP de Dakar, Senegal*

*Abstract-* Recently, irregular sampling techniques have been proposed for the design of digital front-end of a radio receiver. This front-end consist in the interface between the analog front-end and the baseband processing. The advantage of these techniques is the simplification of the sampling frequency conversion and the channel selection. The objective of the proposed work is to study if a gain in power consumption is also obtained. In this paper, the major research is the digital-front-end power consumption by using random sampling. Firstly, we introduce the methods of random sampling JRS (Jitter random sampling) and ARS (Additive random sampling). Then we use these methods to generate the random clock, select the hardware as mixed platform with ADC and FPGA and implement different solutions. At last, we measure the power consumption of different solutions and make a comparison.

*Keywords: JRS, ARS, FPGA, ADC, power consumption.*

*GJRE-F Classification : FOR Code: 090699*

STUDYOFTHEPOWERCONSUMPTIONOFADIGITAL-FRONT-ENDUSINGRANDOMSAMPLING

*Strictly as per the compliance and regulations of :*

# Study of the Power Consumption of a Digital-Front-End using Random Sampling

M. Diop [α], Deng Xiaoyu [σ] & J.-F. Diouris [ρ]

*Abstract-* Recently, irregular sampling techniques have been proposed for the design of digital front-end of a radio receiver. This front-end consist in the interface between the analog front-end and the baseband processing. The advantage of these techniques is the simplification of the sampling frequency conversion and the channel selection. The objective of the proposed work is to study if a gain in power consumption is also obtained. In this paper, the major research is the digital-front-end power consumption by using random sampling. Firstly, we introduce the methods of random sampling JRS (Jitter random sampling) and ARS (Additive random sampling). Then we use these methods to generate the random clock, select the hardware as mixed platform with ADC and FPGA and implement different solutions. At last, we measure the power consumption of different solutions and make a comparison.

*Keywords: JRS, ARS, FPGA, ADC, power consumption.*

## I. Introduction

Before digital signal processing, the signal must be presented in the appropriate digital format. Therefore the original analog signal, before processing, has to be converted into a digital one, i.e. it has to be digitized. Once a signal is digitized, the features of the obtained digital signal are fixed and nothing can be done to change them. In an ideal world, these features would exclusively depend and actually would copy the features of the original analog signal. The reality is different. The two basic operations of any analog to digital conversion, both sampling and quantization, impact the characteristics of the digital signal substantially. The characteristics of the analog signal at the ADC input and of the digital signal at its output are just similar rather than identical. How large and significant the difference between them depends on the digitizing methods and their implementations.

Information carried by an analog signal can be represented in a digital form by a sequence of instantaneous values measured at discrete time instants. These signal readings are usually considered as signal sample values and the process of taking them is referred as sampling. The instants at which the samples are obtained form a stream of events, which can be demonstrated graphically as a sampling point process. Characteristic features of the sampled signals to a large extent depend on the patterns of the point processes generated and used for sampling. When sampling is mentioned in the technique of DSP, usually it is assumed that it is deterministic and uniform (equidistant). The model of sampling according to which signal samples are separated by time intervals with a constant and known duration is the most popular. This is readily comprehensible because such a sampling approach appears to be the most natural and obvious. It also has a number of attractive advantages.

However, as was established relatively long ago, the application of periodic sampling alone is not sufficient. The periodic sampling model is not applicable when fluctuations in sampling instants cannot be ignored or when signal samples can be obtained only at non-uniform or even random time intervals. Studies have indicated that randomness in sampling is not always harmful, random irregularities in sampling sometimes can even be beneficial [1]. These irregularities, if properly introduced, provide, for instance, such a useful effect as the suppression of aliasing. And such sampling itself usually is considered as non-uniform. Depending of the required performance specification of the signal processing system to be developed and given both in functional and performance quality terms, sampling can be adapted by taking the following decision: the choice of either periodic or non-uniform sampling.

While periodic sampling is preferable, in high frequency signal processing cases, the required periodic sampling rate might be too high. Then usage of non-uniform sampling might be better. However special and more complicated signal processing algorithms have to be used in that case. Therefore adapting the sampling operation to the specific signal processing conditions comes down to a trade-off between the complications caused either by high sampling rate or more complex algorithms.

Uniform sampling is preferable whenever the spectrum of the signal can be restricted as required by the Sampling Theorem. Firstly, periodic sampling is the simplest method of performing this procedure and is easy to implement. Secondly, periodic sequences of signal samples are well suited to digital processing. Note only that, many highly efficient fast algorithms are applicable.

Random sampling may prove to be more profitable when it is undesirable or even impossible to

*Author α: Ecole Supérieure Polytechnique, UCAD, BP 5085, Dakar-Fann, Sénégal. e-mail: magdiop2002@yahoo.fr, magaye@ucad.sn*
*Author σ ρ: Ecole polytechnique de l'Université de Nantes, Rue C. Pauc, La Chantrerie, B. P 50609, 44306, Nantes, cedex 03–France.*

pre-filter signals before their analog digital conversion, when the signal to be processed contains components at frequencies exceeding half of the sampling rate. However the essence of randomized sampling is taking the signal sample values at unknown random time instants. Therefore application of randomized sampling is limited to the relatively cases where the information about the exact sampling instants is not relevant.

Pseudorandom sampling is the most often used non-uniform sampling based anti-aliasing technique. The indications for its usage are the same as for the randomized sampling except that the sampling instants in this case are known with high precision.

The significance of the sampling operation is determined by the fact that many essential digital signal characteristics, impacting the whole signal processing process substantially depend on the methods and techniques used to perform it. In the traditional DSP case, the only way to reduce this often undesirable dependence is increasing the sampling frequency. However, the possibilities then are poor and limited. In addition, this approach in many cases produces an increased number of bits requiring more complicated hardware for the subsequent processing of the obtained in these way digital signals. Deliberate introduction, when necessary, of an element of randomness into the sampling operation helps a lot in obtaining the flexibility essential for adaptation of the analog-digital conversion to the conditions of the given specified signal processing task. Therefore the application of non-uniform sampling is more flexible then use of traditional uniform sampling.

In this paper, we propose to use the random sampling method implemented by original design of a Pseudorandom Signal Sampler circuit for controlling ADC to relax constraints of receiver circuits supporting multiband signal processing. This new idea of using non-uniform sampling technique for multiband signals sampling allows the main advantage of suppressing spectral aliases at integer multiples of sampling frequency produced by conventional uniform sampling technique. We expect this reduces the constraints on the anti-aliasing filter, relaxes the automatic gain control dynamic range, and decreases the ADC dynamic power consumption.

Non-uniform sampling theory and techniques are presented in various publications [1-3] and used for some applications such as duty cycle measurement and spectrum analysis. For practical implementation of non-uniform sampling, some non-uniform signal sampler solutions are proposed in the literature [4-7].

The rest of the paper is organized as follows. In section two the theory of random sampling is presented. Three methods of generation of the non-uniform clock and implementation with VHDL on FPGA are detailed in the section three. An analysis of power consumption is presented in section four and comparison is done under different frequencies and using regular and irregular sampling. Finally, a conclusion is given with some directions for future works.

## II. Theory of Random Sampling

The properties of random sampled signals are mainly defined by the mode of generation of point streams used for the implementation of sampling, that is, the selection of points in time for signal readout. Although there are a relatively large variety of known non-equidistant spaced point processes, only a few of them actually have the characteristics required for high performance sampling. The available expertise in application of various random point streams suggests that the most advisable technique for producing sampling instants is based on additive random point process. It is really well suited for the purposes of deliberate sampling randomization. This point process has such remarkable properties and is so flexible that it suits random sampling applications very well. Specifically, sampling carried out in this way ensures that all parts of any input signal are sampled with equal and constant probability. Therefore such sampling is signal-independent. And it provides for unbiased (no systematic errors) estimation of signal parameters, including spectral parameters. However, there are several other point processes which should also be considered because they are connected to relatively frequently observed and important effects such as fluctuation of uniform sampling instants or random selection of uniformly spaced samples.

i. *Jitter Random Sampling*

Fluctuation of sampling instants is a fairly common occurrence [1]. It can even be said that it is always present. In the case of uniform sampling with jitter, signal samples $\{t_k\}$ are taken at time moments $t_k = kT + \tau_k$ , T>0 where T is a period of uniform sampling, but $\{t_k\}$ is a family of identically distributed independent random variables with zero mean. This sampling scheme is illustrated in Figure 1. It shows the probability density functions $p_k(t)$ of time intervals $(t_k - t_0)$. As can be seen from Figure 1(d), this particular function has multiple peaks. Note that as *t* increases the peaks shown do not decrease.

To understand the meaning of the function $p_k(t)$, imagine that a narrow time window $\Delta t$ is moved along the *t*-axis. Under the condition $\Delta t \rightarrow 0$, the function $p_k(t)$ at any arbitrary time instant is equal to the probability that one of the sampling points will fall within this window. Therefore if a signal is sampled at the instants which are determined by the statistical relationship illustrated by Figure1 (d) some parts of the signal will be sampled with a higher probability than others. This is obviously undesirable, as it will lead to the

Global Journal of Researches in Engineering ( F ) Volume XIV Issue III Version I Year 2014

signal processing errors. There is an exception. If the time intervals ($t_k - t_0$) are distributed uniformly in the intervals ($kT \pm 0.5T$) respectively, then the resulting sampling point density function is constant. But in fact this method of generating non-uniform sampling point stream has a number of substantial disadvantages, which prevent its wide application:

- The random variables $\{t_k\}$ should be distributed strictly uniformly within the given intervals
- Time intervals between any two sampling instants may be very short.

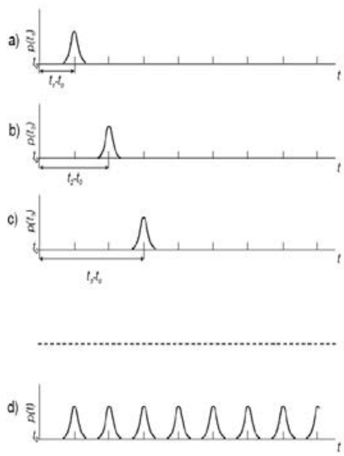


*Figure 1:* Probability density functions characterizing periodic sampling with jitter. a), b) c) probability density functions of a sum of 1, 2 and 3 time intervals, respectively; d) resulting sampling point density function

*b) Additive Random Sampling*

In the case of additive random sampling, signal samples are taken at time moments $t_k = t_{k-1} + \tau_k$, where $\{\tau_k\}$ is a family of identically distributed independent positive random quantities [1]. Such a non-uniform point stream can be easy implemented to suppress the overlapping effect. The degree of randomization can be varied through appropriate selection of only one parameter $-\sigma / \mu$, where $\sigma$ and $\mu$ are the mean value and standard deviation of the intervals between sampling points, respectively. Obviously the mean sampling rate is equal to $1/\mu$. The additive random sampling scheme itself is illustrated by Figure 2.

Probability density function of time interval:

$t_k - t_0 = \tau_1 + \tau_2 + \cdots + \tau_k$ in this case can be calculated as $p_k(t) = p_{k-1}(t) * p_\tau(t)$, where the asterisk * denotes the convolution operation, and $p_\tau(t) = p_1(t)$ is a density function of $\{\tau_k\}$ distribution. As the random variable $t_k - t_0 = \tau_1 + \tau_2 + \cdots + \tau_k$ represents the final result of a linear sum of statistically independent constituent variables, then whatever probability density function these variables may have, the probability density of $(t_k - t_0)$ will approach the normal form as $k$ approaches infinity. As can be seen from Figure 2, the sampling point density function in the case of additive non-uniform sampling with $t$ increasing will always tend to become flat. The value of this constant level is equal to 1/μ. When non-uniform sampling is selected for application in a given case, an appropriate sampling rate has to be set up. The criteria for the choice of an appropriate sampling rate, in the case of non-uniform sampling, completely differ from those commonly used for periodic sampling. The spectral component of the signal with highest frequency to be non-uniformly sampled and processed actually is not a criterion then. The mean sampling rate is calculated by evaluating the number of signal samples needed and the longest time interval during which those samples have to be acquired for one signal realization. While the minimum of the signal samples to be taken at periodic sampling actually is equal to the required number of them in the case of non-uniform sampling, excessive samples often are taken at periodic sampling just to avoid aliasing [1].

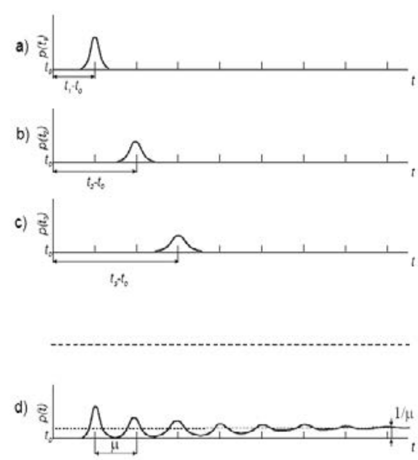


*Figure 2 :* Probability density functions characterizing additive random sampling. a), b) c) probability density functions of a sum of 1, 2 and 3 time intervals, respectively; d) resulting sampling point density function

*c) Multiband signal reconstruction based on SVD*

The multiband signal x=x(t) has a Fourier transform vanishing outside of measure B [2]. Using ARS as the sampling method, write T for the observation interval $t_n - t_1$. A reconstruction of the following form is:

$$x'(t) = \sum c_k \times e^{2j\pi f_k t} \qquad (1)$$

In which the ($f_k$) lie in the B bandwidth and with in each subinterval, are equally spaced. The $c_k$ is found by minimizing the square-error

$$E_{is}^{2} = | AC - x |^{2}, \left( A_{ik=} e^{2j\pi f_k t_i} \right) \qquad (2)$$

The optimum is obtain from the following formulary:

$$A^H \times A \times C = A^H \times X_S \qquad (3)$$

$A^H$ is the conjugate matrix of A.

With the matrix calculation, we can obtain:

$$C = (A^H \times A)^{-1} \times A^H \times X_S \qquad (4)$$

$(A^H \times A)$ is a singular matrix, so we should use a suitable algorithm to solve C.

SVD (singular value decomposition) method is a proper way to resolve the problem. SVD algorithm decomposes A into three matrices:

$$A \times S \times V^H \qquad (5)$$

U and V are matrices with dimension N and M, in addition,

$$U \times U^H = U^H \times U = V^H \times V = V \times V^H = I \qquad (6)$$

S is a diagonal matrix: S=diag($\sigma_1, \sigma_2 \cdots \sigma_p$), and p=min(M,N), $\sigma_1 \geq \sigma_2 \cdots \geq \sigma_p \geq 0$.

Suppose $Z = V^H \times C$ and $Y = S^H \times U^H \times X_S$, the Eq. (3) is equivalent to:

$$S^H \times S \times Z = Y \qquad (7)$$

then we can obtain:

$$Z_k = \frac{Y_k}{S_{kk}^2}, \ k \in [1,\ldots p] \qquad (8)$$

Finally, we can obtain the coefficients $c_k$ :

$$C = V \times Z \qquad (9)$$

In [3], the following empirical results were obtained:

- Good reconstruction was obtained when the design matrix is of full column rank, that is, the columns are independent, and rank (A)/m = 1. A necessary condition is that the sampling rate exceed the Nyquist-Landau rate (or else n < m and the matrix cannot be of full column rank; the rank of a matrix cannot exceed either of its dimensions).
- Regular sampling, sampling in allowed region. The functions are independent with regard to the sampling set, and rank (A)/m =1.
- Regular sampling, sampling rate in disallowed region but above the Nyquist-Landau rate. The functions become folded on top of each other in frequency space, and the columns of A become dependent; therefore, rank (A) falls by an amount proportional to the degree of overlap. However, rank (A)/m> (1/2) because the maximum degree of overlap is seen when one band sits exactly on top of the other, and then, only half the columns become redundant.
- Random sampling. When the average sampling rate was a little over the Nyquist-Landau rate (q < 1; we found q = 0.9 to give acceptable results), the design matrix was of full column rank, and good reconstruction was obtained. However, we did not investigate the effect of having large gaps in the sampling; one would expect these to significantly reduce the quality of reconstruction.

We consider the reconstruction of a multiband of five QPSK modulated carrier signals, show in the Figure 3, each at a symbol rate Rsym =4 sym/s and with a raised cosine filter excess bandwidth factor of 0.5. Each carrier is separated by 8 Hz; therefore, the group band occupies a theoretical bandwidth of 38 Hz. We construct the original signal using a fine regular sampling grid ($\tau_k$) at 1000 Hz. A typical realization of the signal and its power spectral density (PSD) is shown in Figure 4 when the center frequency is 175Hz.

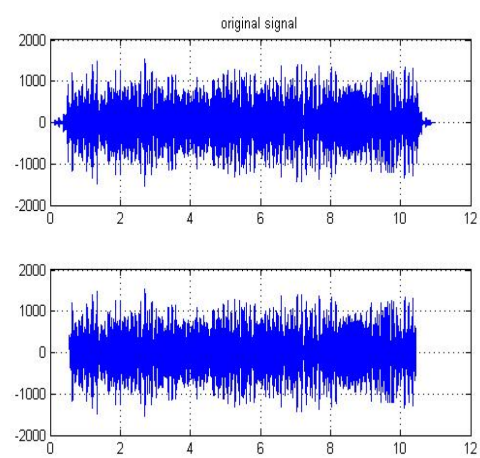



*Figure 3 :* QPSK modulated signals

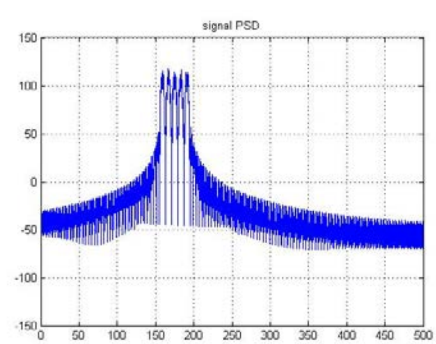



*Figure 4 :* Power Spectral Density

To obtain the sampled signals, we decimate the original sample set in two ways: regularly and irregularly. In the first case, the sampling rate is 100 Hz; in the second, the average sampling rate is 100 Hz. So we sample the QPSK signal by using regular, ARS and JRS and reconstruct the signal based on SVD.

Figure 5 illustrate the signal sampled by ARS and reconstruct with SVD.

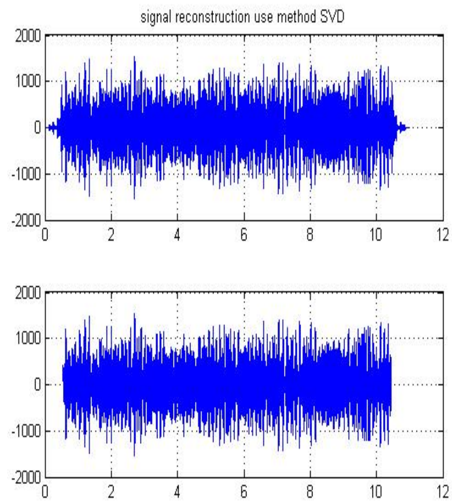



*Figure 5 :* Method SVD with ARS

In Figure 6, it show that signal sampled by JRS and reconstruct with SVD.

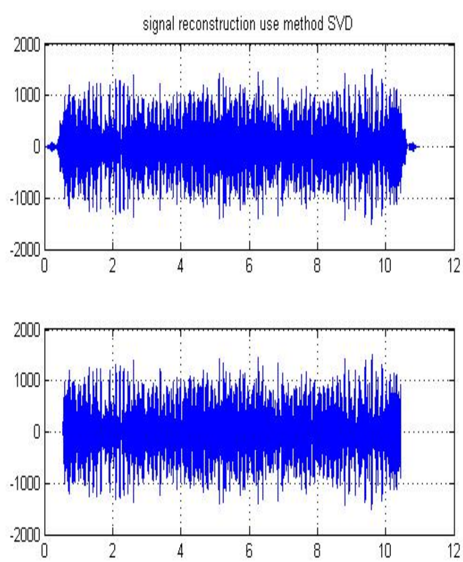



*Figure 6 :* Method SVD with JRS

And in Figure 7, it demonstrates the regular sampling and reconstructs the signal using SVD.

We also calculate the average SNR and error of each way:

SNR (ARS) = 58.657809, E (ARS) =0.0109

SNR (JRS) =59.662221, E (JRS) =0.0076

SNR (unif) =67.479956, E (unif) =0.0066

With these result, we can consider that the randomized sampling scheme can be used for the multiband signal without the restrictions on sampling rate.

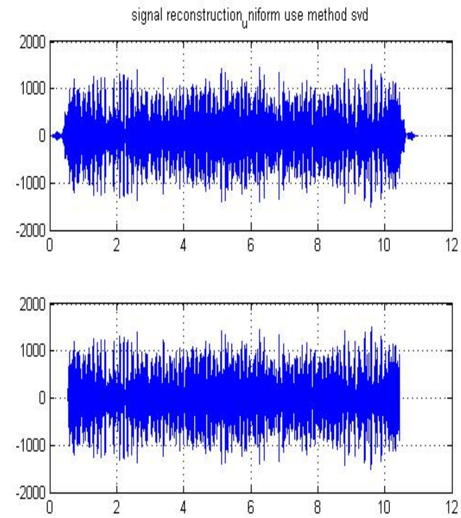



*Figure 7 :* Method SVD with regular sampling

## III. Generation of Random Clock and Implementation of FPGA

Based on the previously chapter, we have two ways to generate the random sampling. In the following parts, we introduce three methods to generate the non-uniform clock, and implement with VHDL on FPGA.

### *a) Pseudorandom Clock Generation*

#### i. *Non-Uniform Processing Formulation*

In [4], non-uniform sampling process, used in this work, converts a continuous analog band pass signal x(t) into its discrete representation $x_s(t)$ as describe in eq.(10):

$$x_s(t) = x(t) \sum_{k=-\infty}^{+\infty} \delta(t - t_k) \tag{10}$$

The sampling instant sequence $\{t_k\}$ is defined as $\{t_k, k \in Z\} \neq \{kT_s, k \in Z\}$ with $T_s$ the mean of the sampling period. This random sequence can be defined by either jitter random sampling (JRS) [1], or additive random sampling (ARS) [1]. To obtain $t_k$ in JRS scheme, we add a random time $\tau_k$ to deterministic instants $kT_s$. However, to obtain $t_k$ in ARS scheme, we add $\tau_k$ to the previous sampling instant $t_{k-1}$ . If irregularities are appropriately chosen, they could provide the aliasing suppression. Alias-free processing is met when the sampling point density function assumes a constant value equal to the mean sampling frequency $f_s$ given by equation (11):

$$p(t) = \sum_{k=0}^{+\infty} p_k(t) = \frac{1}{T_s} = f_s \tag{11}$$

where $p_k(t)$ is the probability density function of the random sampling point $t_k$ . This stationary condition is accomplished in case of ARS scheme, and in case of JRS scheme only for uniform probability density over [ $-\frac{1}{2}T_s, \frac{1}{2}T_s$ ].

Nevertheless, random sampling is not convenient to generate and precisely recover uniform sampling instants. In most non-uniform sampler implementations, the sampling instants are, either randomly or pseudo randomly, analogically generated. Then, the sampling generated instants are digitized before being used in digital recovering process [6]. In [1], Wojtiuk proposed the time quantized random sampling scheme. Each random time $\tau_k$ , is quantized to $\tau_{q,k}$ and represented by Eq. (12) according to Eq. (13):

$$\tau_{q,k} = n\Delta \text{ with } \Delta = \frac{T_s}{q_T} \tag{12}$$

$$(n-1/2)\Delta < \tau_k \leq (n+1/2)\Delta \tag{13}$$

Where $q_T$ is the quantization time factor and *n* a positive integer number. The TQ-RS in case of JRS scheme for $q_T$ =4 is illustrated in Fig.8 [7].

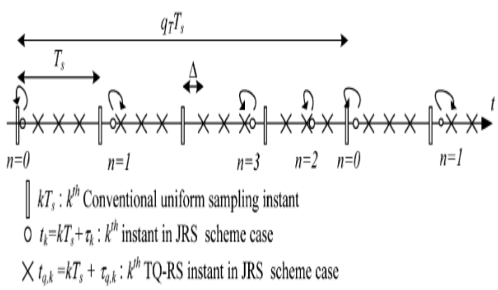



*Figure 8 :* Time-Quantized Random Sampling (TQ-RS) for $q_T$ =4

ii. *Circuit of Pseudorandom Signal Sampler*

To sample non-uniformly, we define several sampling phases instead of conventional uniform sampling. The solutions based on phases, noted $\{\Phi_0, \Phi_1 \cdots, \Phi_{q_T-1}\}$ and it present the required phases for TQ-RS for $q_T = 8$ in Fig.9. The delay between the two successive clock phases is the minimum spacing $\Delta$ defined in Eq. (12), and the phases duty cycles are equal.

We propose a design to generate the random clock using these different phases but the same frequency clocks. Fig.10 illustrates the block diagram of the circuit [5].

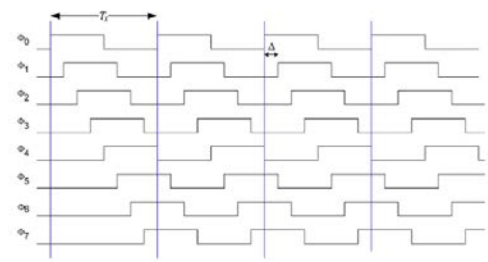



*Figure 9 :* TQ-RS for $q_T$ =8

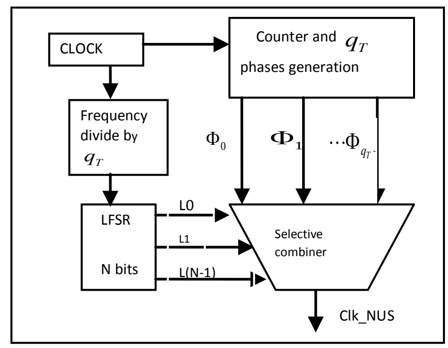



*Figure 10 :* Block Diagram for random clock

a. *Counter and Combiner*

To overcome overlap, it is better to use gray counter outputs combined to deliver the needed phase for the non-uniform sampling. The sampling time is the rise edge of the available phases. The counter is controlled by CLK and is based on a shift register with $\log_2 q_T$ flip-flops. In this case, the resulting generated phases for non-uniform sampling are presented in fig.9.

b. *Linear Feedback Shift Register (LFSR)*

Phases generated, from the counter and combiner, are selected according to a random number. Linear feedback shift registers make extremely good pseudorandom pattern generators. When the outputs of the flip-flops are loaded with a seed value (anything except all 0, which would cause the LFSR to produce all 0 patterns) and when the LFSR input a clock, it will generate a pseudorandom pattern of 1and 0. A LFSR with n length characteristic polynomial G[x] generates a binary pseudorandom sequence each period $p = 2^n - 1$ when initial state is non zero. LFSR synthesis requires at least n flip-flops. Here we propose to generate pseudorandom numbers using an LFSR composed of $\log_2 q_T$ flip-flops at CLK/ $q_T$ rate. In our previous example, we need an LFSR as represented in fig.11. The characteristic polynomial is given by Eq. (14)

$$G(x) = 1 + x + x^3 \tag{14}$$

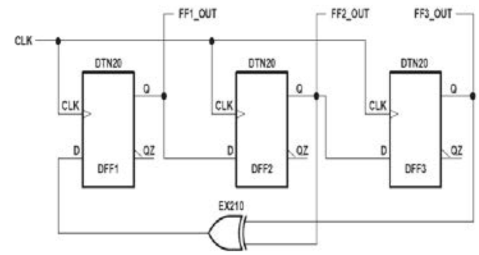



*Figure 11 :* LFSR architecture

*c. Selective Combiner*

Having the different sampling phases and the pseudorandom number, we have to introduce a selective combiner to select the phase according to the delay $i\Delta$ where $i$ is the pseudorandom number generated by the LFSR being in the set $\{0,1\cdots q_{T-1}\}$. The selective combiner is a multiplexer $q_T$ inputs to one output controlled by $\log_2 q_T$ signals.

*d. General Results*

In fig.12, phases generated by the counter and combiner ( $\Phi_0,\Phi_1\cdots,\Phi_{q_T-1}$ ), pseudorandom numbers " $L_2L_1L_0$ " and the result pseudorandom clock CLK_NUS are given.

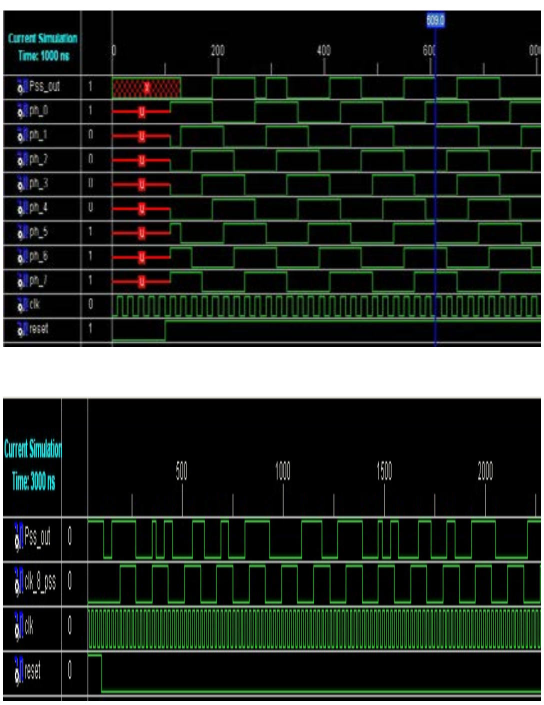


*Figure 12 :* General Results

*b) Random Clock Generation*

Previously in the chapter 3, we use pseudorandom number to generate the non-uniform clock, the algorithm of the method is approximate JRS. In the following part, we propose to generate another random clock, it is approximate ARS.

Figure 13 gives the architecture of the circuit. In this case, the component of Random clock generator contains a register, in Figure 14, which have N bit, and from the N-1 to N-M-1

Bits are '1', the others are '0'. From this register, we can define the average sampling frequency:

$$f_s = \frac{M}{N} \times f_o \qquad (15)$$

$f_o$ is the frequency of FPGA original clock.

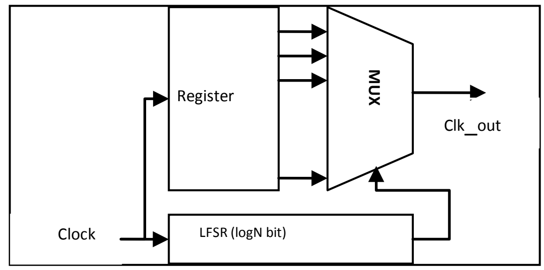



*Figure 13 :* Random clock generator

With the LFSR, we propose to use the longer length LFSR. Because with this we can generate the long periodic number which can improve the sampling to the full extent of randomization. In this design, when the LFSR generate a number, meanwhile it will select the correspond position in the register, and if the position is '1', the clk_out will output '1'.

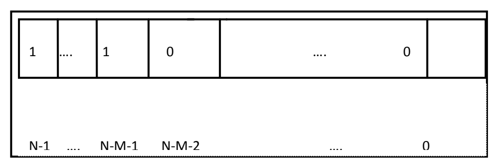



*Figure 14 :* Register of Random clock generator

For example, if N=32 and M=7, the LFSR can generate 5 bits pseudorandom numbers, with the program; in fig.15, there is the simulation of the application.

Furthermore, if we want to obtain more precise result, we can modify N and M, for instance, N=512 and M=10, LFSR can generate 9 bits pseudorandom numbers, according to Figure 16, the simulation show that pseudorandom sampling in long period is better than in short one, it is more close to the real random sampling.

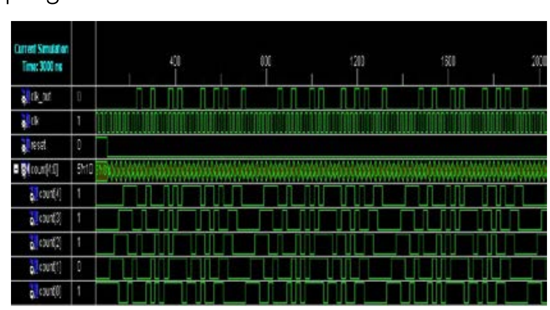


*Figure 15 :* LFSR: Generation of 5 bits pseudorandom numbers

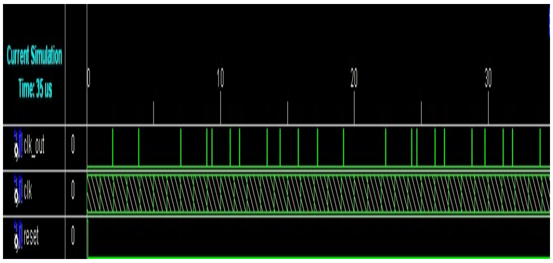


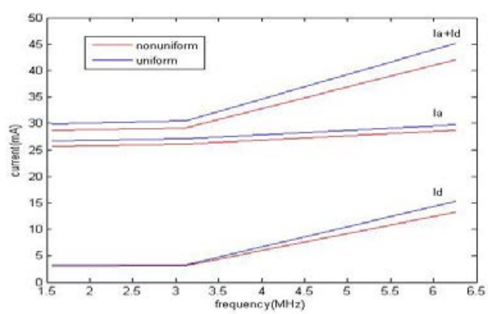

*Figure 16 :* LFSR: Generation of 9 bits pseudorandom numbers

## IV. Comparison of the Power Consumption

Based on the generation of random clock, we can make a measurement of power consumption with ADC and FPGA platform, and comparison the power consumption under different clock frequencies, also compare the regular sampling and irregular power consumption.

*a) Results of using pseudorandom clock*

The input signal to ADC equal to 750 KHz, amplitude is 2.6V. We measure the voltages and calculate the currents with sampling frequency equal to 1.56MHz, 3.12MHz and 6.25MHz. In Figures 17-18, it demonstrates the results both uniform and non-uniform.




(a)

*Figure 17 :* Comparison results with pseudorandom clock

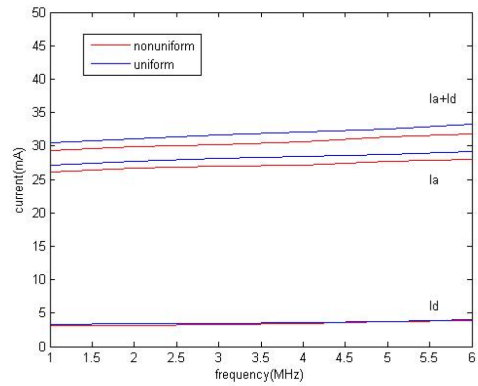
| A/D / Nun/Un / Frequency | | AVDD Current (mA) | DVDD Current (mA) | $I_A + I_D$ |
|---|---|---|---|---|
| $f_1$ =1.56MHz | Nonuniform | 25.641 | 3.061 | *28.702* |
| | Uniform | 26.666 | 3.265 | *29.931* |
| $f_2$ =3.12MHz | Nonuniform | 26.154 | 3.078 | *29.232* |
| | Uniform | 27.180 | 3.278 | *30.458* |
| $f_3$ =6.25MHz | Nonuniform | 28.718 | 13.27 | *41.988* |
| | Uniform | *29.750* | *15.31* | *45.060* |

(b)

*Figure 17 :* Comparison results with pseudorandom clock

*b) Results of using approximately random clock*

The input signal of ADC equal to 500 kHz, amplitude is 2.6V. We measure the voltages and calculate the currents with a sequence of sampling frequency. Figures 19-20 illustrate the results both uniform and non-uniform.




(a)

*Figure 18 :* Comparison results with approximately random clock

| A/D / Nun/Un / Frequency | | AVDD current (mA) | DVDD Current (mA) | $I_A + I_D$ |
|---|---|---|---|---|
| $f_1$ = 6 MHz | Nonuniform | 27.95 | 3.88 | *31.83* |
| | Uniform | 29.23 | 3.98 | *33.21* |
| $f_2$ =5MHz | Non-uniform | 27.69 | 3.67 | *31.36* |
| | Uniform | 28.72 | 3.78 | *32.50* |
| $f_3$ =4MHz | Nonuniform | 27.18 | 3.47 | *30.65* |
| | Uniform | 28.46 | 3.57 | *32.03* |
| $f_4$ =3MHz | Nonuniform | 26.93 | 3.265 | *30.195* |
| | Uniform | 28.21 | 3.47 | *31.68* |
| $f_5$ =2MHz | Nonuniform | 26.67 | 3.16 | *29.83* |
| | Uniform | 27.69 | 3.37 | *31.06* |
| $f_6$ =1MHz | Nonuniform | 26.15 | 3.11 | *29.26* |
| | Uniform | 27.18 | 3.265 | *30.445* |
| $f_7$ =500kHz | Nonuniform | 25.64 | 3.07 | *28.71* |
| | *Uniform* | ---- | ---- | |

(b)

*Figure 18 :* Comparison results with approximately random clock

## V. Conclusion

According to these result above, we can observe in Fig.18-20 that the current increases when the sampling frequency increases. While compare the currents between the uniform and non-uniform, the former is larger than the latter one.

Compare the results which are deduced from the two kind of non-uniform clocks, when we use the same sampling frequency, the current is not the same. Aim to prove the second random clock is more precise than the first one, with the second clock used in & 3.2, we propose to M=1&N=8 and M=16&N=128; with these two groups, the $f_{av}$ both equals to 6.25MHz. Implemented on the ADC, the first group M&N obtains the result as same as using the first method (&3.1.2), while with the second group M&N, the result I measured is lower than the result of first group. Obviously we can consider that the second method is more precise than the first one.

In conclusion, with nonuniform clock, the current is lower than using the uniform clock, we can consider that random sampling can decrease the ADC dynamic power consumption.

## VI. Future Work

In this case, if we can verify the reconstruction of the signal with the random sampling, it will be more compellent. So I propose to obtain the samples and sampled time form the FPGA card and demonstrate in the oscillograph, to be certain that using random sampling can decrease the power consumption of ADC and also reconstruct the signal completely. After these work, we can continue to measure the power consumption on FPGA and make comparison among the different situations.

## References Références Referencias

1. J. J. Wojtiuk, Randomized Sampling for Radio Design, "Ph. D. Thesis", University of South Australia, School of Electrical and Information Engineering, 2000.
2. Jeffrey J. Wojtiuk and Richard J. Martin, "Random Sampling Enables Flexible Design for Multiband Carrier Signals, "IEEE TRANSACTIONS ON SIGNAL PROCESSING, VOL. 49, NO. 10, OCTOBER 2001.
3. R. J. Martin and D. A. Castelow, "Reconstruction of multiband signals using irregular sampling", GEC J. Tech., vol. 14, pp. 180–185, 1997.
4. Manel BEN-ROMDHANE, Chiheb REBAI, Adel GHAZEL, "Pseudorandom Clock Signal Generation for Data Conversion in a Multistandard Receiver", 2008 International Conference on Design & Technology of Integrated Systems in Nanoscale Era.
5. Chiheb Rebai, Manel Ben-Romdhane&al, "Pseudorandom signal sampler for relaxed design of multistandard radio receiver," Microelectronics Journal 40 (2009) ", pp.991-999.
6. N. Michael, S. Shah, J. Das, M. M. Sandeep, C. Vijaykumar, "Nonuniform digitizer foralias-free sampling of wide band analog signals", in IEEE Region 10 Conference, TENCON2007, October–November 2007, pp.1–4.
7. Haïfa FARES, Manel BEN-ROMDHANE, Chiheb REBAI, "Non Uniform Sampled Signal Reconstruction for Software Defined Radio Applications", 2008 International Conference on Signals, Circuits and Systems.

This page is intentionally left blank

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 14 Issue 3 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

# Frequency Dependent Planar Electromagnetic Modeling of Human Body and Theoretical Study on Attenuation for Power Budget Estimation of UWB Radar

By Kedar Nath Sahu, Dr. Challa Dhanunjay Naidu & Dr. K Jaya Sankar
*Stanley College of Engineering and Technology for Women, India*

*Abstract-* Detection of the heartbeat rate and/or respiration rate are very important for most radar based applications like lie-detection, life-detection etc. The prediction of signal losses is a fundamental aspect in the design of ultra wide-band radars. The effect of body tissues surrounding the heart is important in the design of a radar system used for heartbeat detection. The broad variety of tissues and their frequency dependent behavior makes accurate attenuation prediction very difficult without the support of an appropriate model. In this paper, two frequency dependent planar electromagnetic models viz. intrinsic impedance model (a classical model) and impedance transformation model, both incorporating dispersive dielectric properties are discussed. Signal attenuations in both models are estimated and compared. This estimation can be helpful in the design of an ultra wideband (UWB) radar system meant for cardio-pulmonary activity related applications.

*Keywords: ultra wideband (uwb), radar, modeling, signal attenuation, reflection coefficient, power budget etc.*

*GJRE-F Classification : FOR Code: 090607, 290903p*

FREQUENCYDEPENDENTPLANARELECTROMAGNETICMODELINGOFHUMANBODYANDTHEORETICALSTUDYONATTENUATIONFORPOWERBUDGETESTIMATIONOFUWBRADAR

# Frequency Dependent Planar Electromagnetic Modeling of Human Body and Theoretical Study on Attenuation for Power Budget Estimation of UWB Radar

Kedar Nath Sahu α, Dr. Challa Dhanunjay Naidu σ & Dr. K Jaya Sankar ρ

*Abstract-* Detection of the heartbeat rate and/or respiration rate are very important for most radar based applications like lie-detection, life-detection etc. The prediction of signal losses is a fundamental aspect in the design of ultra wide-band radars. The effect of body tissues surrounding the heart is important in the design of a radar system used for heartbeat detection. The broad variety of tissues and their frequency dependent behavior makes accurate attenuation prediction very difficult without the support of an appropriate model. In this paper, two frequency dependent planar electromagnetic models viz. intrinsic impedance model (a classical model) and impedance transformation model, both incorporating dispersive dielectric properties are discussed. Signal attenuations in both models are estimated and compared. This estimation can be helpful in the design of an ultra wideband (UWB) radar system meant for cardio-pulmonary activity related applications.

*Keywords: ultra wideband (uwb), radar, modeling, signal attenuation, reflection coefficient, power budget etc.*

## I. Introduction

For many applications such as lie detection, life detection etc. remote detection/monitoring of cardio-pulmonary features of a human being such as heartbeat rate, breath rate, and blood flow rate etc. are necessary. This can be done to good accuracy using high resolution radars like ultra wide-band radars. Moreover, human body monitoring using UWB technology can permit the subject to be in absolutely free space as it uses radiated field unlike other methods e.g. functional-MRI (f-MRI) uses induced EM field. A summary of the existing models found in the literature are presented below.

*Author α: Professor, Department of Electronics and Communication Engineering, Stanley College of Engineering and Technology for Women, Hyderabad, Andhra Pradesh, India.*
*e-mail: knsahu72@gmail.com*
*Author σ: Professor in the Department of Electronics and Communication Engineering and Principal of VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, Andhra Pradesh, India. e-mail: cdnaidu@yahoo.com*
*Author ρ: Professor and Head of the Department of Electronics and Communication Engineering, Vasavi College of Engineering, Hyderabad, Andhra Pradesh, India. e-mail: kottareddyjs@gmail.com*

Radar monitoring of human physiologic functions started in early 70's as mentioned in [1] but further progress was stopped as the technique was expensive. Micro-power Impulse Radar (MIR), an UWB radar model was developed by Thomas E. McEwan at Lawrence Livermore National Laboratory (LLNL) during 1993 which was able to detect the movements of heart wall from the difference of reflection magnitude between various tissue interfaces. This model proposed in both of the patents on medical UWB radar awarded to McEwan [2-3], did not account for the various living tissues through which the UWB pulse travels before it strikes the heart wall and hence is quite ingenuous. Another more accurate model described in [4] was found at Tor Vergata University of Rome, Italy that accounted for thickness, impedance, linear attenuation and wave velocity of six superimposed living tissues (air, fat, muscle, cartilage, deflated lung and heart) encountered by the UWB pulse passing through the chest from skin to heart. This model was based on the data taken from Visible Human Project [5] and Gabriel's data book of dielectric properties of tissues [6]. As an immediate application of this model the author of this model [4] developed the UWB radar based stealthy lie detector [7]. The attenuation predicted by the model given in [4] was linear but the imaginary part of reflection coefficient and multiple reflections were ignored. In [4], author himself mentioned that this new model remains intrinsically wrong as the dielectric properties used were measured on living tissues using a continuous-wave (CW) of frequency 1500 MHz. The analysis was based on only one frequency and therefore was frequency independent. Hence the author suggested for a more effective model by using ultra wide-band dielectric properties instead of narrow band ones for which a convolution method or a Finite Difference Time Domain (FDTD) technique should be used and also by considering both the real and imaginary parts of the reflection coefficients at the boundaries because the UWB receiving correlator, working in the time domain, is strongly sensitive to phase errors. In 2006, two frequency-dependent EM modeling techniques: planar technique and FDTD technique were presented [8] which could predict the response of a four layer biological model with three layers of normal tissue and one layer of cancerous soft tissue to input UWB signal. The thickness of each layer in the models was taken from the Visible Human Project [5] and dielectric properties of tissues from Gabriel's data book [6] as followed by the earlier model presented in [4]. As far as the planar technique is concerned the authors mentioned that the technique produces reasonable results for applications of less number of layers but not very accurate for more complex layers as it does not consider to model multiple reflections and hence suggested that the planar technique could be extended to include provision for multiple reflections.

A circuital model for monitoring of cardio-pulmonary activity with UWB radar of operating frequency range of 0.1 to 3 GHz was presented in 2008 by Pisa et.al [9]. This model was developed taking the signal source, transmitting and receiving antenna properties as well as a planar model of human thorax into account. The thorax model considered the same tissues: air, fat, muscle, cartilage, lung and heart as used in the model employed in [4]. The attenuation of the air-heart-air path was evaluated over the ultra wideband frequency of 0.1 to 3 GHz for two types of lungs: deflated lung and inflated lung. It was found that the model has predicted attenuation increase with frequency and moreover the amount of attenuation increase is more in case of deflated lung than that in case of inflated lung [9]. This planar model was a circuital model but, an electromagnetic (EM) model could be a more approximate model over circuital model.

Both the UWB models reported in [4] and [9] ignored the skin tissue in the thoracic modeling but attenuation due to skin tissue is also significant because skin is also one of the greatest electromagnetic field absorbing tissues like muscle and blood in the human body as reported in [10]. Moreover, the circuital model given in [9] is frequency dependent whereas the model described in [4] was developed for a continuous wave of 1.5 GHz and hence was a frequency independent model. A frequency dependent planar model described in [8] considers skin but did not include the phenomenon of multiple reflections.

Also, calculations pertaining to incident, reflection and transmission components of power at every interface are considered, which are not calculated and reported by any of the models. An investigation of these effects such as accounting for the electromagnetic information due to skin, the phenomenon of multiple reflections, frequency dependence of signal attenuation is the subject of this paper.

In this paper, two frequency-dependent planar electromagnetic models of human thorax: the intrinsic impedance or classical model and the impedance transformation model are reported in which both models incorporate the dispersive behavior of selected biological tissues including skin. When the impedance transformation model takes care of the effect of multiple reflections, the classical model does not consider that effect. First, without including skin in the modeling, the signal attenuation results are obtained and compared with the attenuation results reported in the circuital model of [9]. Then the signal attenuation results from the heart with skin included in both the models are analyzed and compared.

As skin tissue is included in the thoracic modeling and particularly, the multiple reflections are also taken care of by the impedance transformation model the signal attenuation results predicted by the models presented in this paper are considered to be more realistic than the model-predicted attenuation of the circuital model reported in [9].

## II. Theoretical Background

In order to study the behavior of the backscattered field from a human body illuminated by plane electromagnetic waves of a radar transmitter, simplification of the problem is considered by modeling the human body as a series of biological tissue layers of complex impedances. Knowing the dielectric properties of the biological tissues, and by utilizing the basic principles of electromagnetic wave propagation in accordance with the physical processes that determine the speed of propagation and the amount of attenuation, the power received by the radar receiver, the electric field (E-field) reflection coefficients at every interface and power reflection coefficient of the heart can be determined.

### *a) Electromagnetic Modeling of Human Body*

In order to model the electromagnetic response of human body to radar waves, it is necessary to know with sufficient precision the electromagnetic characteristics of typical biological tissues used to build the body. For this purpose, the transverse section of human anatomy taken from web [11] as shown in Fig.1 is referred. The figure depicts the human thorax showing the contents of the middle and the posterior mediastinum. The pleural and pericardial cavities are exaggerated since normally there is no space between parietal and visceral pleura and between pericardium and heart. Various tissues like sternum, hard cholesterol, muscle, ribs, costal pleura, pleural cavity, pulmonary pleura, pericardium cavity, heart, pulmonary artery (left and right), aorta, internal mammary vessels, thoracic aorta, esophagus, bronchus, thoracic duct, body of thoracic vertebrae, lungs (left and right) etc. encounter in the path of propagation partly or fully, when the human body is illuminated by the radar wave. Let us consider only some of the major biological tissues such as skin, fat, muscle, cartilage, lungs (deflated and inflated separately) and heart as the fundamental layers for a simple one-dimensional modeling of human body. As electromagnetic behavior due to heartbeat movements are of interest, assuming the radiation exposure from anterior of the of the human body to the posterior through heart, the tissue structure considered in view of the electromagnetic body modeling is as shown in Fig.2.

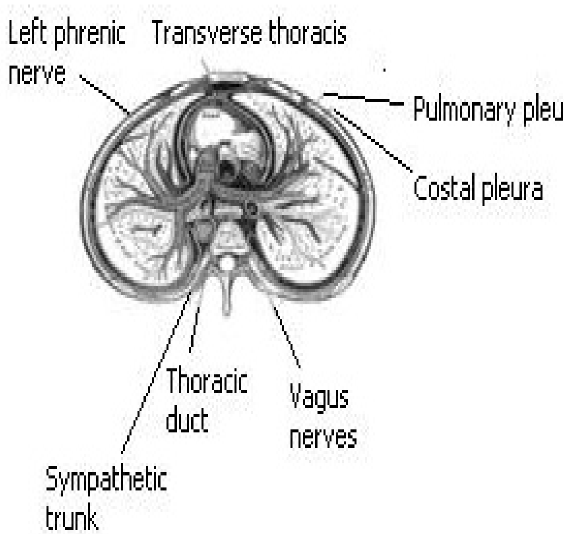
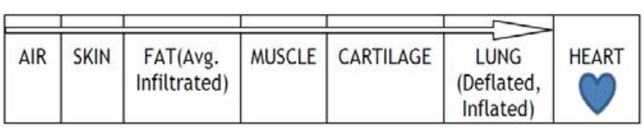
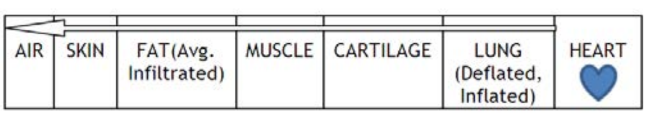



*Figure 1 :* Transverse section of human thorax [11]




(a)




(b)

*Figure 2 :* Tissue structure for EM modeling of human body (a) forward propagation (b) backward propagation

The anatomical thickness values of the tissue layers (Table 1) considered in both of the models are based on the Visible Human Project [5] like those already employed in the UWB models of [4], [7-10].

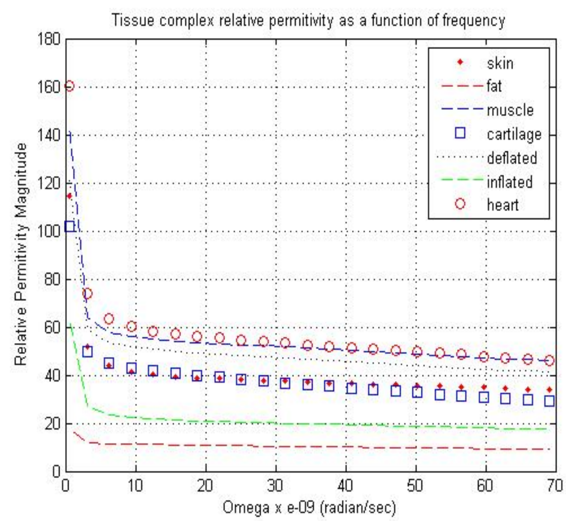
*Table 1 :* Anatomical thickness of tissue layers

| Tissue name | Thickness (mm) |
|---|---|
| Air | 200 |
| Skin(Dry) | 1.5 |
| Fat | 9.6 |
| Muscle | 13.5 |
| Cartilage | 11.6 |
| Lung | 5.78 |

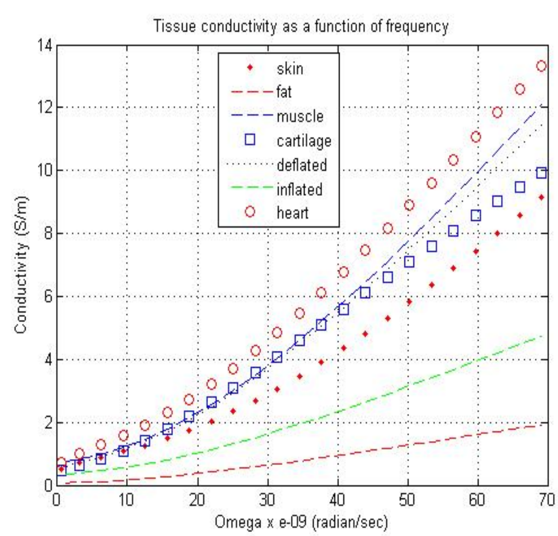
*b) Frequency dependent dielectric properties of tissues in human thorax*

Based on the Cole and Cole equation as mentioned in [9] that describes the dispersive behavior of tissues, the frequency dependent dielectric bodies of human body tissues are computed as given in the Gabriel's data book of dielectric properties of tissues [6] and are also reported on the web [13].

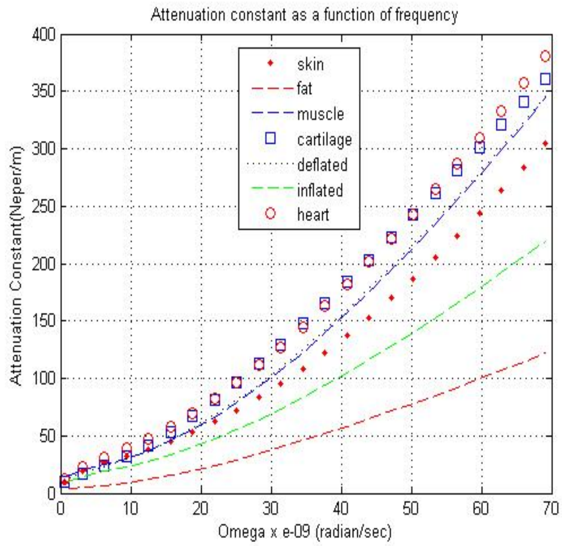
In our work, the dielectric properties such as complex relative permittivity, conductivity, attenuation constant, phase-shift constant, complex impedance and velocity of wave propagation of the selected tissues for modeling at all frequencies of 0.1 to 3 GHz ultra-wideband are taken from [6]. The variations of the above dielectric properties as a function of frequency are plotted in Fig.3. It is seen that as frequency increases, relative permittivity decreases, but conductivity, attenuation constant, phase-shift constant and intrinsic impedance increase as shown in Fig. 3(a) – (e) respectively.



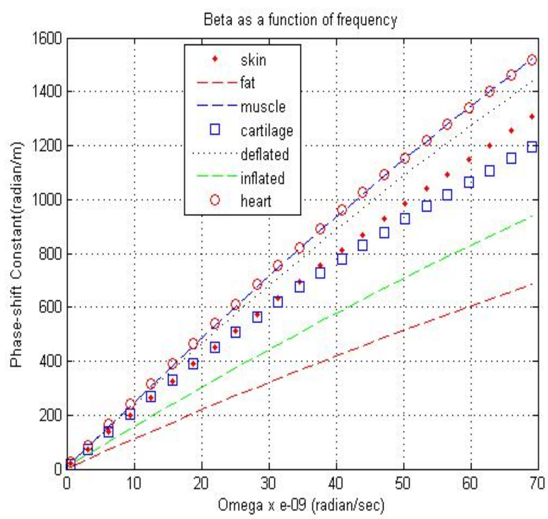

(a)



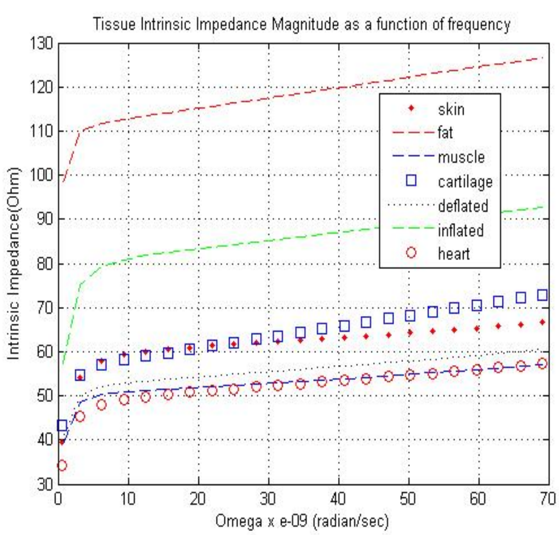

(b)




(c)




(d)




(e)

*Figure 3 :* Variation of (a) relative permittivity (b) conductivity (c) attenuation constant (d) phase-shift constant (e) impedance of tissues with frequency

## III. Electromagnetic Analysis

When an electromagnetic wave is incident on an interface between two consecutive tissue layers a part of the EM energy is transmitted and the remaining is reflected [8] as shown below in Fig.4. The amount of reflection and transmission of energy depends on the frequency dependent dielectric properties of the layers on either side of the interface.

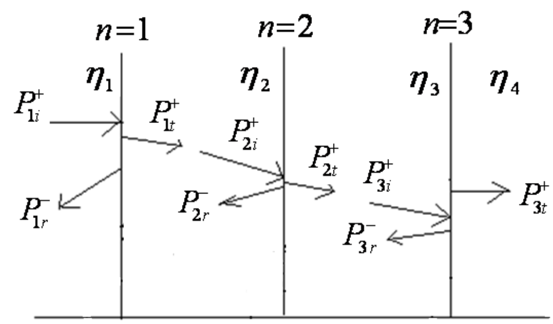



*Figure 4 :* Intrinsic Impedance Model

As biological tissues are lossy media, from an electromagnetic point of view they are characterized in terms of the attenuation constant, phase-shift constant, conductivity, complex permittivity, complex impedance, complex reflection coefficient etc. These characterization parameters are highly frequency dependent. Therefore, the reflected and transmitted power at all tissue interfaces calculated at every individual frequency of the ultra wide-band range using the concept of EM wave propagation in lossy media are as described in [14].

### *a) Propagation in Lossy Media*

Wave losses due to electric field are described through complex permittivity, $\epsilon$. Similarly, complex permeability, $\mu$ is used to model the losses owing to medium response to the magnetic field.

But from wave propagation point of view in most of the materials, the magnetic response is usually very weak compared to the dielectric response. Therefore,

$$\mu \cong \mu_0 \text{ i.e. } \mu_r' = 1, \mu_r'' = 0$$

Consequently, wave losses can be confined to the loss due to the complex permittivity only assuming $\mu$ entirely real for the analytical loss calculation.

As in [14-15], for a lossy dielectric media

$$D = \epsilon E \tag{1}$$

$$J = \sigma E \tag{2}$$

$$B = \mu H \tag{3}$$

where

$$\epsilon\text{, Complex permittivity} = \epsilon' - j\epsilon'' = \epsilon_0\left(\epsilon_r' - j\epsilon_r''\right) \qquad (4)$$

and

$$\mu\text{, Complex permeability} = \mu' - j\mu'' = \mu_0(\mu_r' - j\mu_r'') \qquad (5)$$

*b) Characterization of loss*

Considering the human tissues as homogeneous, isotropic, and dispersive media, the characterization parameters such as complex propagation constant ($\gamma$), complex attenuation constant ($\alpha$), complex phase-shift constant ($\beta$) and complex intrinsic impedance($\eta$) as defined in [14-15] are given as below.

Propagation constant, $\gamma = \alpha + j\beta = \omega\sqrt{\mu\epsilon} = \omega\sqrt{\mu(\epsilon' - j\epsilon'')}$

$$= \sqrt{\mu\epsilon'\left(1 - j\frac{\epsilon''}{\epsilon'}\right)} \qquad (6)$$

Now,

Re $\{\gamma\} = \alpha$, attenuation constant

$$= \omega\sqrt{\frac{\mu\epsilon'}{2}}\left(\sqrt{1+\left(\frac{\epsilon''}{\epsilon'}\right)^2} - 1\right)^{1/2}$$

$$= \omega\sqrt{\frac{\mu\epsilon'}{2}}\left(\sqrt{1+(\text{LossTangent})^2} - 1\right)^{1/2} \qquad (7)$$

and

Im$\{\gamma\} = \beta$, phaseshift constant

$$= \omega\sqrt{\frac{\mu\epsilon'}{2}}\left(\sqrt{1+\left(\frac{\epsilon''}{\epsilon'}\right)^2} + 1\right)^{1/2}$$

$$= \omega\sqrt{\frac{\mu\epsilon'}{2}}\left(\sqrt{1+(\text{LossTangent})^2} - 1\right)^{1/2} \qquad (8)$$

where $\quad \text{LossTangent} = \frac{\epsilon''}{\epsilon'} = \frac{\sigma}{\omega\epsilon'} \qquad (9)$

The characteristic impedance of a medium is given by

$$\eta = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\epsilon}} = |\eta|\, e^{j\theta_\eta} \qquad (10)$$

Magnitude of complex impedance, $\eta$ can be given by,

$$|\eta| = \frac{\sqrt{|\mu/\epsilon|}}{\left\{1 + \left|\left(\frac{\sigma}{\omega\epsilon}\right)\right|^2\right\}^{1/4}}$$

$$|\eta| = \frac{\sqrt{|\mu/(\epsilon' - j\epsilon'')|}}{\left\{1 + \left|\left(\frac{\sigma}{\omega(\epsilon' - j\epsilon'')}\right)\right|^2\right\}^{1/4}}$$

$$\Rightarrow |\eta| = \frac{\sqrt{\mu_0/\epsilon_0}\sqrt{|1/(\epsilon_r' - j\epsilon_r'')|}}{\left\{1 + \left|\left(\frac{\sigma/\omega\epsilon_0}{(\epsilon_r' - j\epsilon_r'')}\right)\right|^2\right\}^{1/4}}$$

$$= \frac{\dfrac{377}{\{(\epsilon_r')^2 + (\epsilon_r'')^2\}^{1/4}}}{\left\{1 + \dfrac{(\sigma/\omega\epsilon_0)^2}{\{(\epsilon_r')^2 + (\epsilon_r'')^2\}}\right\}^{1/4}} \qquad (11)$$

Phase of complex impedance can be given by,

$$\theta_\eta = \frac{1}{2}\tan^{-1}\left|\frac{\sigma}{\omega\epsilon}\right| \qquad (12)$$

$$= \frac{1}{2}\tan^{-1}\frac{\sigma/\omega\epsilon_0}{\{(\epsilon_r')^2 + (\epsilon_r'')^2\}^{\frac{1}{2}}} \qquad (13)$$

In this way the electromagnetic propagation through a medium is modeled.

## IV. Power Calculations

Using the power relations given in [14-15] as a general rule for average power transfer per unit area through reflection and transmission about an interface separating two lossless dielectric regions 1 and 2, incident, reflected and transmitted power for every interface can be determined.

$$\text{Incident power,} \quad P_i^+ = \frac{(E_1^+)^2}{2\eta_1} \qquad (14)$$

$$\text{Reflected power,} \quad P_r^- = \frac{(\Gamma E_1^+)^2}{2\eta_1} = |\Gamma|^2\frac{(E_1^+)^2}{2\eta_1} = |\Gamma|^2 P_i^+ \qquad (15)$$

$$\text{Transmitted power,} \quad P_t^+ = (1 - |\Gamma|^2)P_i^+ \qquad (16)$$

When the power carried by the radar wave is incident on any interface, 'n' separating the two tissue mediums 'n' and 'n+1', known as incident power during forward propagation, $LP_{ni}^{+}$, part of it is transmitted to the next layer in the same forward direction, known as transmitted power, $LP_{nt}^{+}$ and the remaining power is reflected into its previous layer in the backward direction known as reflected power component, $LP_{nr}^{-}$. The amount of power reflected from every interface keeps getting retransmitted in a backward propagation mode and is finally received at the receiver. Such retransmitted power components from each of the interfaces received by the radar receiver in a backward propagation mode is known as reflected power component during backward propagation, $(LP_{nr}^{-})'$. The transmitted power or the reflected power respectively through or from every interface during any mode of propagation, forward or backward should be multiplied by the power attenuation factor of the corresponding layer before entering into the next tissue layer.

## V. The Planar Models

Two planar techniques for modeling the propagation of electromagnetic waves (i.e. the UWB pulses) through human tissues are presented: the intrinsic impedance model (or classical model) and the impedance transformation model. It will be shown that both of the planar models can predict better signal attenuation as they take into account several important factors missing in the earlier models. However, the impedance transformation model predicts more subtle phenomena such as multiple reflections and hence is a more appropriate model. First, a five layer configuration: fat-muscle-cartilage-lung-heart is used to study attenuation of signal from heart and then the analysis is repeated for a six layer configuration: skin-fat-muscle-cartilage-lung-heart to know the attenuation contributed due to inclusion of skin. Both deflated and inflated lung types are used separately for a comparison.

### *a) Intrinsic Impedance Model*

This is a multi-layered model having layers of different dielectric properties as depicted in Fig.4. The thickness and dielectric properties of the individual layers of the tissue structure are the constitutive parameters of the model. The velocity of propagation of a signal depends on the tissue permittivity and both permittivity and conductivity determine the attenuation of the signal. The reflection and transmission of signals take place at the interfaces between consecutive tissues and is obtained from the difference in impedance of the layers on either side of the interface. The intrinsic impedance of tissue layers separated by interfaces as shown in Fig.5 depends on the frequency dependent dielectric properties and hence is frequency dependent as well.

In general, considering a multi-layer system and assuming normal incidence, the E-field complex reflection coefficient of n-th layer is given by

$$\Gamma_n = \frac{E_{n_r}}{E_{n_i}} = |\Gamma_n|\, e^{j\phi_n} = \frac{\eta_{n+1} - \eta_n}{\eta_{n+1} + \eta_n} \quad (17)$$

where $\Gamma_n$ is the reflection coefficient of the interface $n$ between the layers $n$ and $n+1$; $\eta_n$ and $\eta_{n+1}$ are the complex impedances of layers, n and n+1 respectively according to the concept of reflection of uniform plane waves at normal incidence. The electric field (E-field) reflection coefficients during forward propagation for every interface between consecutive layers of the model are obtained using the Eq.17 which will be useful for calculation of powers across the interfaces.

### *b) Impedance Transformation Model*

In the event of wave reflection from multiple interfaces, impedance transformation method considers complicated sequence of multiple reflections in every region or layer as explained in [14]. Following the three-interface case related to the concept of wave reflection for multiple interfaces as shown in Fig.5 and using the boundary conditions at the tissue interfaces, we can have,

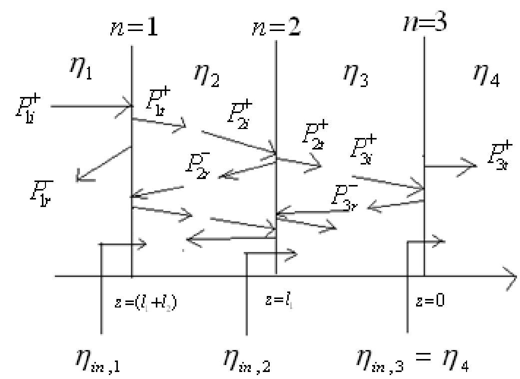



*Figure 5 :* Impedance Transformation Model

Input impedance at n=2,

$$\eta_{in,2} = \eta_3 \frac{\eta_4 \cos\beta_3 l_3 + j\eta_3 \sin\beta_3 l_3}{\eta_3 \cos\beta_3 l_3 + j\eta_4 \sin\beta_3 l_3} \quad (18)$$

Input impedance at n=1,

$$\eta_{in,1} = \eta_2 \frac{\eta_{in,2} \cos\beta_2 l_2 + j\eta_2 \sin\beta_2 l_2}{\eta_2 \cos\beta_2 l_2 + j\eta_{in,2} \sin\beta_2 l_2} \quad (19)$$

Now, reflection coefficient at interface n=1 can be given by,

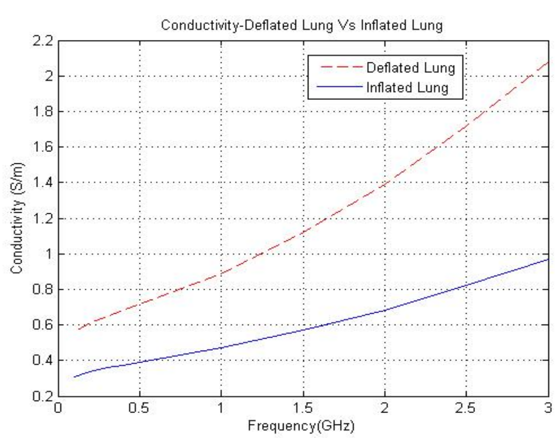
$$\Gamma_1 = \frac{\eta_{in,1} - \eta_1}{\eta_{in,1} + \eta_1} \quad (20)$$

Similarly, considering the six-layered tissue system of both of the models the input impedance and reflection coefficient corresponding to every other tissue interface are obtained using a MATLAB program and are then used for power calculations.

## VI. Results

The backward reflected power from the heart i.e. the heart-lung interface of the air-heart-air path is the attenuation due to the UWB pulse echo for the frequencies in the band 0.1 to 3 GHz are calculated. This attenuation predicted by both classical model and impedance transformation model are obtained separately for the cases of deflated lung and inflated lung. Such attenuation results are also obtained for both lung types separately for without-skin and with-skin cases to know the contribution of skin tissue to attenuation. All attenuation results thus calculated are analyzed and compared with each other and also with the attenuation results reported by the circuital model [9] as well.

A comparison of conductivity, reflection coefficients at the lung-heart interface of both intrinsic impedance model and impedance transformation model is shown in Fig.6. It is clear that the conductivity of both deflated lung and inflated lung increase with frequency, the reflection coefficients of both lung types decrease with frequency. Also, at any frequency, deflated lung has higher conductivity and hence lesser reflection coefficient than inflated lung.




(a)

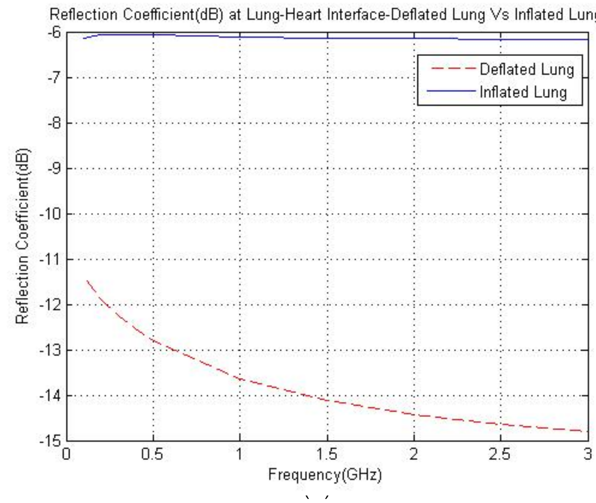
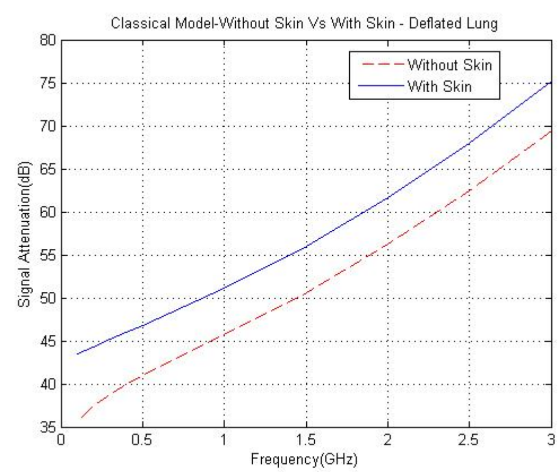
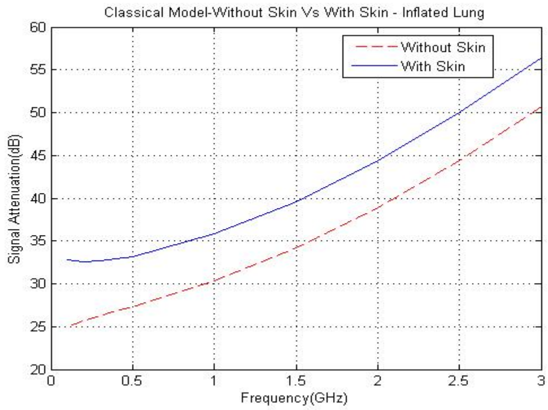



*Figure 6 :* Variation of (a) conductivity (b) reflection coefficient at the heart-lung interface – Deflated lung Vs Inflated lung

Attenuation increases with increase of frequency for both cases of without-skin and with-skin and moreover an additional attenuation in the order of 5 to 8 dB is found due to the inclusion of skin in the classical model [Fig. 7(a) and (b)]. Additional attenuation exclusively due to inclusion of skin is found in case of the impedance transformation model also [Fig. 8(a) and (b)]. However, in the later model, the amount of additional attenuation due to inclusion of skin is smaller at some frequencies as compared to that found in case of the classical model.



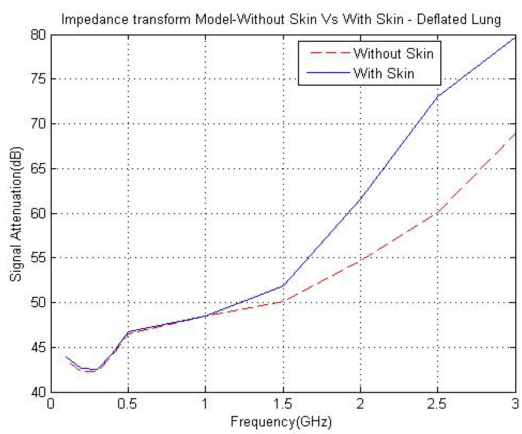

(a)



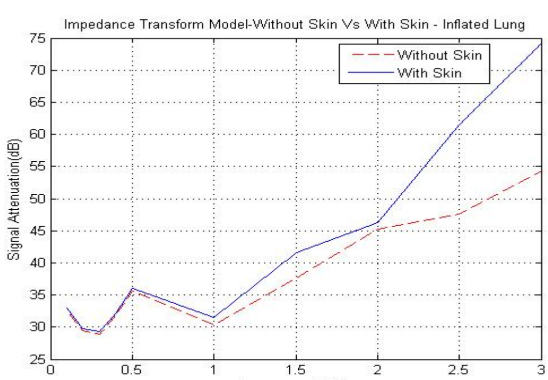

(b)

*Figure 7 :* Comparison of classical model predicted signal attenuation in decibels between without skin and with skin cases (a) deflated lung (b) inflated lung

The comparative analysis between deflated lung and inflated lung cases of both classical model as well as impedance transformation model each considering without-skin and with-skin cases are shown below in Fig. 9(a)-(d).

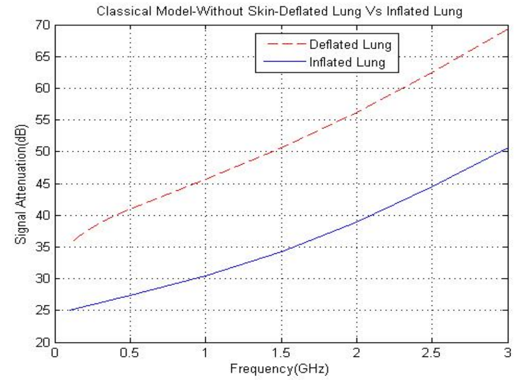



(a)

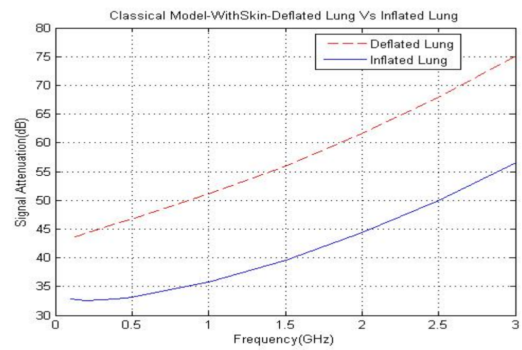



(b)

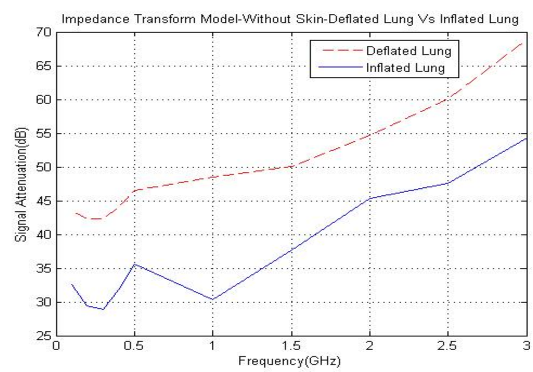
*Figure 8 :* Comparison of impedance transform model predicted signal attenuation in decibels between without skin and with skin cases (a) deflated lung (b) inflated lung



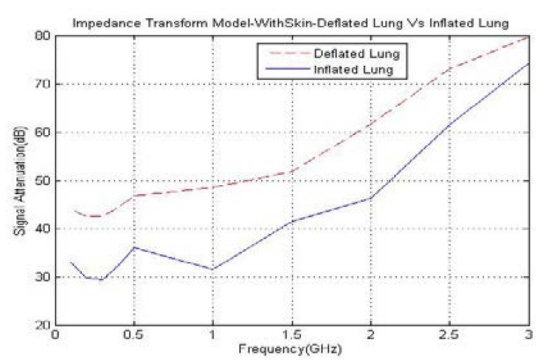

(a)




(b)




(c)




(d)

*Figure 9 :* Comparison of signal attenuation between deflated lung and inflated lung types for (a) classical model (without skin case) (b) classical model (with skin case) (c) impedance transform model (without skin case) (d) impedance transform model (with skin case)

In both of the models it is found that the increase of attenuation is higher in case of deflated lung than that in case of inflated lung for both without-skin and with-skin cases. This is due to the fact that deflated lung has higher conductivity [Fig.6(a)] and hence lesser reflection coefficient than inflated lung [Fig.6(b)].The amount of increase of attenuation from inflated to deflated lung at a particular frequency is the same between without-skin and its corresponding with-skin case of the same model. Such an increased attenuation characteristics from inflated to deflated lung was reported in the circuital model [9] but the models presented in this work predict more attenuation for both deflated and inflated lung cases.

## VII. Conclusions

Remote monitoring applications based on detection of heart and breath rates are effective because it is difficult to suppress completely the heartbeat and respiration related subjects' motions. Also, the propagation of waves through the subjects' body is mainly governed by the electromagnetic characteristics of body tissues. The electromagnetic response of the human tissue is highly frequency dependent.

In this paper, both of the frequency dependent electromagnetic models of human body presented incorporate the electromagnetic properties of body tissues including the skin tissue corresponding to a 0.1 to 3 GHz ultra wide-band (UWB) radar. The lossy power coefficients at all tissue interfaces are evaluated during both forward and backward propagations of UWB pulses. The reflection from the cardiac structure i.e. the heart wall has been quantified and a comparative analysis on attenuation due to the pulse-echo intensity is presented. The complex reflection coefficients and complex impedances of tissue layers are considered in this one-dimensional analytical solution as they are important for the validity of power budget analysis. The advantage of the planar impedance transformation model is the implicit inclusion of the electromagnetic wave phenomenon such as multiple reflections, taking place during propagation through multiple interfaces.

Owing to the inclusion of the effect of skin tissue in the planar modeling along with the implicit provision for multiple reflections, the impedance transformation model can have better prediction ability of signal attenuation in the design of UWB radars. Future work will involve the application of impedance transformation model for other biological applications for study of signal attenuation. Results of such complex and sophisticated biological models shall help to build and test signal processing techniques in non-invasive, remote monitoring applications like home health care, emergency rooms, intensive care units (ICUs) in hospitals, pediatric clinics to alert for sudden infant death syndrome (SIDS), radar based lie detection, remote life detection etc. the heartbeat signal power thus derived can be processed further to obtain heart beat information.

## References Références Referencias


1. Franks, C. I., Brown, B. H., and Johnston, D. M. (1976), "Contactless respiration monitoring of infants". Med. Biol. Eng, Vol.14, No.3, pp.306-318.
2. McEwan, Thomas. E., (1996), "Body monitoring and imaging apparatus and method". United States Patent 5, 573,012.
3. McEwan, Thomas. E., (1998), "Body monitoring and imaging apparatus and method", United States Patent 5, 766,208.
4. Staderini, E. M., (2002), "UWB radars in medicine". IEEE Aerospace and Electronic System Magazine, Vol.17, No.1, pp.13-18.
5. Chang, Y. J., (1997), "The NPAC visible human viewer". Syracuse University, New York.
6. Gabriel, C., (1996), "Compilation of the dielectric properties of body tissues at RF and microwave frequencies". Report N.AL/OE-TR-1996-0037, Occupational and environmental health directorate, Radio frequency radiation division, Brooks Air Force Base, Texas, USA.
7. Staderini, E. M., (2003), "An UWB radar based stealthy lie detector". In: Mokole EL, Kragalott M, Gerlach KR, editors. Ultra-Wideband, Short-Pulse Electromagnetics 6. New York, USA: Kluwer Academic/ Plenum publishers, pp. 537-552.
8. Martin, O. H., Martin, G., and Jones, E. (2004), "Frequency-dependent modeling of ultra-wideband pulses in human tissue for biomedical applications". International Workshop on Ultra wide-band Systems Joint with Conference on Ultra wide-band Systems and Technologies, pp.161 – 165.
9. Pisa, S., Bernardi, P., Cavagnaro, M. et. al. (2008), "Monitoring of Cardio-pulmonary activity with UWB radar: A circuital model". Asia-Pacific symposium on Electromagnetic Compatibility and 19th International Zurich Symposium on Electromagnetic Compatibility, Singapore.
10. Chirwa, L.C., Hammond, P.A., Roy, S., and Cumming D. R. S. (2003). "Electromagnetic radiation from ingested sources in the human intestine between 150 MHz and 1.2 GHz". IEEE T Bio-med Eng., Vol. 50, pp.483-492.
11. An internet resource for the transverse section of human thorax: http://en.wikipedia.org/wiki/File:-Gray968.png (as visited on January 2010).
12. Barber, P. W., Gandhi, O. P., and Hagmann, M. J., and Chatterjee, I. (1979) Electromagnetic absorption in a multilayered model of man. IEEE T. Biomed. Eng. Vol. BME-26, No.7, pp.401-405.
13. An internet resource for the calculation of the dielectric properties of body tissues. Institute for Applied Physics, Italian National Research Council

http://niremf.ifac.cnr.it/tissprop/. (as downloaded on January 2010).

14. Hayt, W. H. and Buck, J. A. (2006). Engineering electromagnetic. (7th ed.). India: Tata McGraw-Hill.
15. Sadiku, M. N. O. (2007). Elements of electromagnetics. (4th ed.). India: Oxford University Press.

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 14 Issue 3 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

# Optimal Location of STATCOM in Nigerian 330kv Network using Ant Colony Optimization Meta-Heuristic

By Aribi Fughar & Nwohu, M. N.

*Federal University of Technology, Nigeria*

*Abstract-* This paper introduces the ant colony meta-heuristic technique to optimally locate STATCOM in 330kV Nigerian Network. The Ant Colony Optimization (ACO) algorithms used the STATCOM parameters and probabilistic model to generate solutions to the problem of siting STATCOM in Nigerian network. The optimal location of STATCOM in Nigerian network is evidenced in bus voltage profile enhancement and minimization of transmission losses. The probabilistic model is called pheromone model which consists of a set of model parameters, often referred to as pheromone values. At run-time, the ACO algorithms try to update the pheromone values from previously generated solutions in such a way that the probability to generate high quality solutions increases over time. Finally, the graph of pheromone trail and path treaded by the ants along the various nodes are captured whose codes are validated using the Matrix Laboratory Software (MATLAB) environment.

*Keywords: STATCOM, 330kv nigerian network, ant colony optimization (ACO), FACTS devices & MATLAB.*

*GJRE-F Classification : FOR Code: 090699*

OPTIMALLOCATIONOFSTATCOMINNIGERIAN330KVNETWORKUSINGANTCOLONYOPTIMIZATIONMETAHEURISTIC

# Optimal Location of STATCOM in Nigerian 330kv Network using Ant Colony Optimization Meta-Heuristic

Aribi Fughar [α] & Nwohu, M. N. [σ]

*Abstract-* This paper introduces the ant colony meta-heuristic technique to optimally locate STATCOM in 330kV Nigerian Network. The Ant Colony Optimization (ACO) algorithms used the STATCOM parameters and probabilistic model to generate solutions to the problem of siting STATCOM in Nigerian network. The optimal location of STATCOM in Nigerian network is evidenced in bus voltage profile enhancement and minimization of transmission losses. The probabilistic model is called pheromone model which consists of a set of model parameters, often referred to as pheromone values. At run-time, the ACO algorithms try to update the pheromone values from previously generated solutions in such a way that the probability to generate high quality solutions increases over time. Finally, the graph of pheromone trail and path treaded by the ants along the various nodes are captured whose codes are validated using the Matrix Laboratory Software (MATLAB) environment.

*Keywords: STATCOM, 330kv nigerian network, ant colony optimization (ACO), FACTS devices & MATLAB.*

## I. Introduction

Generally, in Engineering the concept of exactness and specific location for device placements is of paramount importance. As a result, certain measures/algorithms are being developed to achieve such goal.

In recent years, many research works have been devoted to the use of optimization technique, particularly as regards power system applications. Owing to the cost effectiveness of the FACTS devices generally, the installation of STATCOM in power system network should be done in such a way as to select the optimal locations to enhance system parameters and maintain proper control of them once installed beside the capital cost [3]. These reasons have made many researchers to propose various techniques of Heuristics methods for siting the FACTS device. Among these techniques of Heuristics methods are the Genetic Algorithm and Ant-Colony [3].

Many researchers have shown that colonies behaviour can be seen as natural model of collective problem solving. The analogy between the way ants look for food and combinatorial paradigm, which is called ant colony meta-heuristic elucidates the appropriateness of this technique in siting FACTS devices [1].

Nwohu, [7] explored a sensitivity based FACTS device placement for improving static and transient stability, whereas in obtaining the finest location of installation, the research used a sensitivity index for selecting the suitable buses.

The ant colony approach optimization to shunt capacitor placement on distribution systems under capacitor switching constraints, indicates that the optimum capacitor allocation solution is possible for the system of feeders fed through their transformer and not for any individual feeder [9].

The Ant Colony Optimization (ACO) technique for Optimal Reactive Power Dispatch (ORPD) has also been made to improve voltage stability condition along with transmission loss and voltage profile monitoring. They pointed that there is a set of cooperating agents called "ant" to find the optimal point of reactive power dispatch [5].

However, in this paper it is aimed to come up with an algorithm that will be suitable in placing the STATCOM on the Nigerian 330kV transmission grid system. The Ant Colony Optimization Technique is found to be appropriate in the optimal placement of STATCOM on the Nigerian grid system.

## II. The Nigerian Grid System

The Nigerian Grid System constitutes the principal core study system in this research work. Herein, the grid system is conveniently zoned into four geographical areas in conformity with operational structure of the electric utility [6, 8]. The three hydro power stations are situated in Area 1 while Area 2 has thermal power station located in it and areas 3 and 4 have gas power stations located in them. The Nigerian National Grid is characterized by poor voltage profile in most parts of the network (especially in the Northern region), inadequate dispatch and control infrastructure, radial and fragile grid network, frequent system collapse, and exceedingly high transmission losses.

The current social impacts of the 330kV Nigerian Transmission Grid system and the growth in environmental requirements have not only called for the expansion of the existing grid but demanded more for the optimization of the grid [2].

*Author α σ: Department of Electrical and Electronics Engineering, Federal University of Technology, Minna. e-mail: aribifughar@yahoo.com*

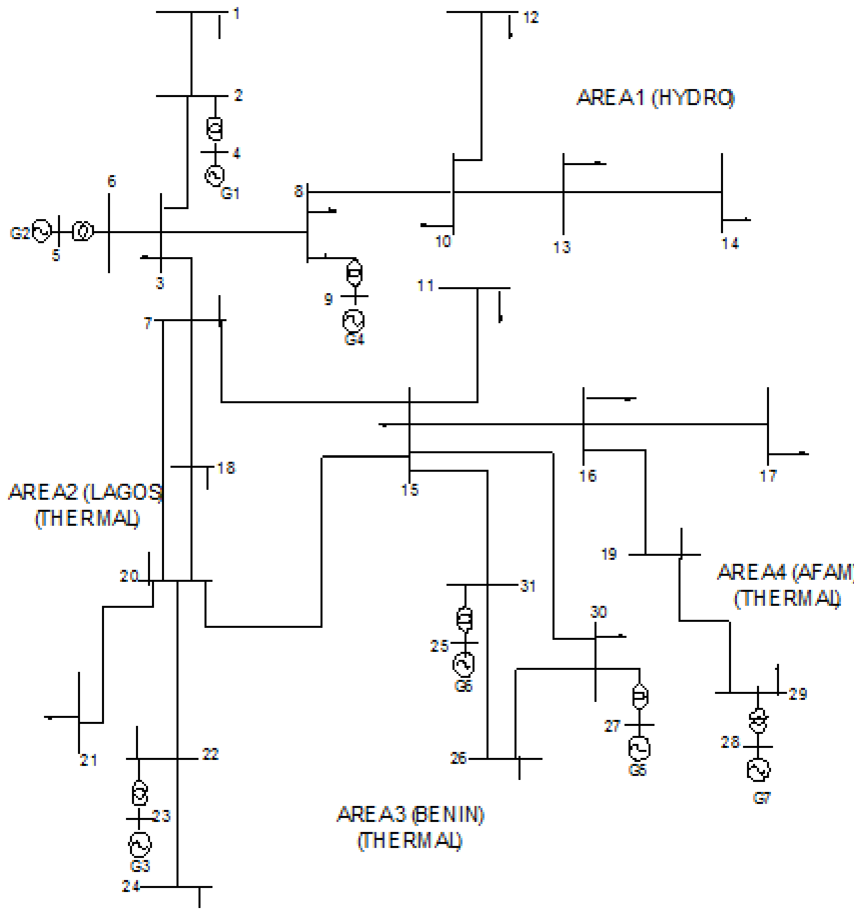



*Figure 1.0 :* Structure of the Nigerian Grid System as at 2007

*a) Operational problems of Nigerian power system*

Almost all electricity consumers in Nigeria have expressed concern over the deterioration of quality of electrical power supply in Nigeria. Power utilities are required to provide electrical energy to consumers as economically and reliably as possible with high efficiency and according to load schedules. However, frequent interruption of electrical power supply in Nigeria has become a regular feature that constitutes problem of loss of goods and services for consumers and the power utilities. Undoubtedly, this situation has led to the rapid growth of standby electric power supply in large consumer premises and domestic dwellings. Even when power is available from the distribution network, problems of low voltage have damaged a lot of voltage-sensitive industrial plants and instruments as well as domestic appliances. Therefore, in order to ameliorate the situation of instability of the Nigerian power network, an appropriate FACTS device is introduced to the system, hence, STATCOM. This, of course, will make the system stable and reliable [10, 4].

## III. Ant-Colony Heuristic Approach

Research has proven that insect colonies behaviour can be seen as natural model of collective problem solving. The analogy between the way ants look for food and combinatorial paradigm is called ant colony meta-heuristic.

This meta-heuristic uses the ant colony optimization (ACO) method. The ant colony can be seen as a simulation of a set of agents that cooperate to find a solution of an optimization problem by means of uncomplicated communications.

The inspiration was taken from the observation of real ants. Ants are social insects living in colonies. It was observed that a moving ant deposits some pheromone (in variable quantities) on the ground; hence making the path it follows [1].

Next ant moving towards the feeding area can identify the pheromone left by the previous ant, decide with high probability to follow it, and reinforce the selected trail with its pheromone. This form of indirect communication mediated by pheromone lying is called stigmergy.

Ants make use of pheromone in order to find a shortest path between two points connected with two branches. If there is no pheromone, ants decide randomly which path to choose. Therefore, more pheromone deposited on the lower path determines the number of new ants that will choose this path willingly

[1]. However, the ants in the ant system are different from natural ants. They have memory, they are not completely blind, and they live in an environment where time is discrete or discontinuous.

Characters of the ACO algorithms use the device parameters and probabilistic model to generate solutions to the problem under consideration. The probabilistic model is called pheromone model. The pheromone model consists of a set of model parameters, which are called pheromone values.

At run-time, the ACO algorithms try to update the pheromone values in such a way that the probability to generate high quality solutions increases over time. The pheromone values are updated using previously generated solutions [1].

*a) Ant Colony Algorithm*

The key idea is that, when a given ant has to choose between two or more paths, the path that was more frequently chosen by other ants in the past will have a greater probability of being chosen by the ant. Therefore, trails with greater amount of pheromone are synonyms of shorter paths.

Figure 1.1a, 1.1b, 1.1c and 1.1d demonstrate how real ants find a shortest path.

In Figure 1.1a, the ants are moving from food source L to the nest R on a straight line and arrive at a decision point.

Once an obstacle appears as shown in Figure 1.1b, some ants choose the upper path and some the lower path. The choice is random. Figure 1.1c depicts the fact that since ants move at approximately a constant speed, the ants which choose the lower, shorter, path reach the opposite decision point faster than those which choose the upper, longer, path. That is, will collect larger amount of pheromone than the longer. In Figure 1.1d, as Pheromone accumulates at a higher rate on the shorter path, the number of dashed lines is approximately proportional to the amount of pheromone deposited by ants.

Therefore, more ants will be increasingly guided to move on the shorter path. Due to this autocatalytic process, very soon all ants will choose the shorter path. This behavior forms the fundamental paradigm of the ant colony search algorithm [1].

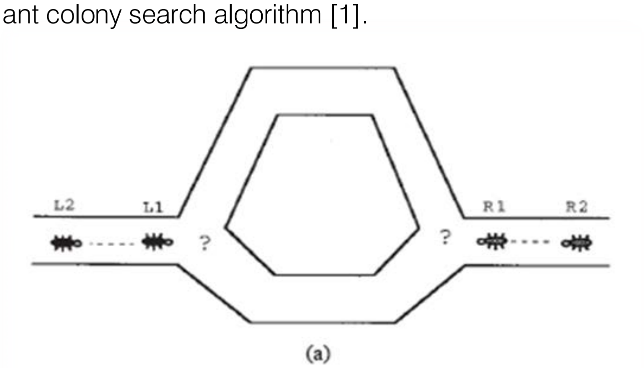



*Figure 1.1a :* Initial Stage

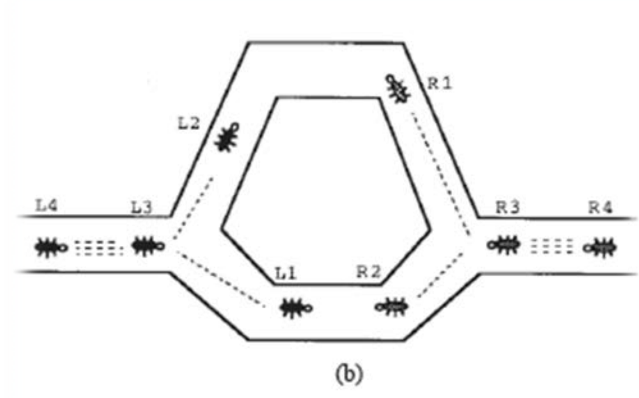



*Figure 1.1b :* Decision Stage

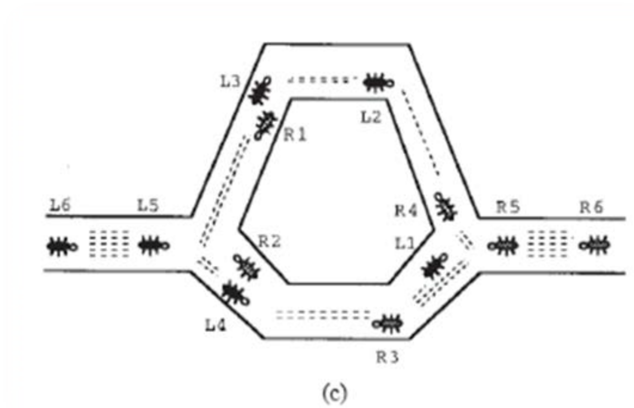



*Figure 1.1c :* Progressive Stage

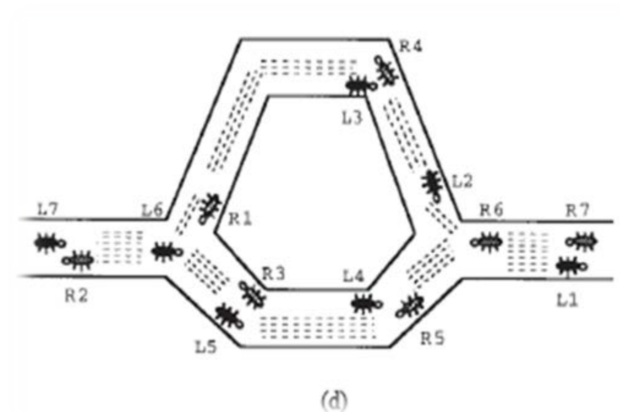



*Figure 1.1d :* Updating Stage

Below is a flow chart describing the processes or stages to actualizing the algorithm as shown in Figure 1.2.

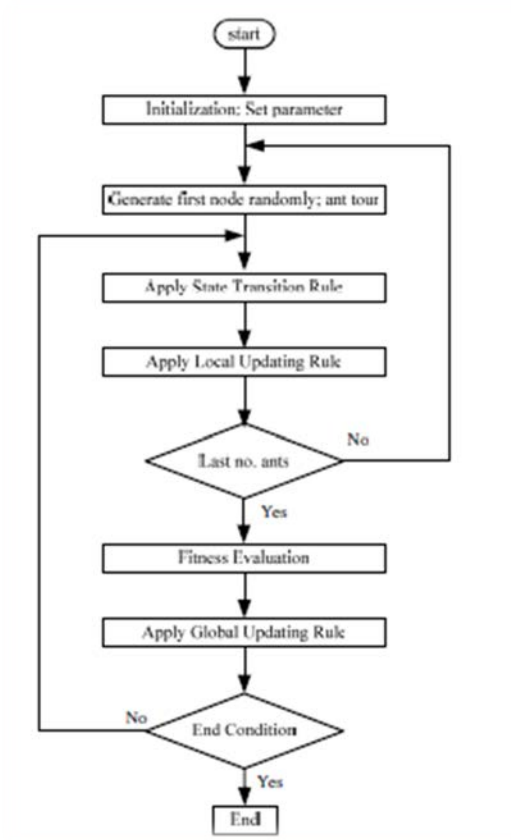



*Figure 1.2 :* Flow chart for Ant Colony Optimization

- **The initialization step:** In this step ants are placed in the initial position and an amount of $\tau_0$ is taken for initial pheromone.
- **Tour calculation:** The distance between parameters is calculated by generating the first Node (bus) randomly. The first node selected further generates random numbers according to a uniform distribution ranging from 1 to n; n>0.
- **Model estimation (Transition Rule):** In this stage, the ant located at the current node will choose the next node and if the system is not satisfactory, the ant will move to the next location based on the probabilistic transition function and pheromone is converged.
- **Local Updating Rule:** The optimal location of FACTS Device is achieved as ants visit edges and change their pheromone level.
- **Fitness Evaluation:** This is performed when all ants have completed their tours.
- **Global Updating Rule**: This figure out the best ant tour which gives the best fitness among all the ants.
- **Repeating Criterion:** The algorithm stop the iteration when a maximum number of iteration have been performed, otherwise, the tour calculation process is repeated.

## IV. Analysis of the Case Study by Load Flow under Fault Condition

In order to demonstrate the effect of the STATCOM on the network under consideration, certain scenarios are considered and analyzed in PSCAD environment as follows.

*a) Without STATCOM*

A single line-to-earth fault was initiated at 0.2sec and cleared at 0.75sec; the system experiences a sharp swing which gradually leads to a total collapse of the entire network. During the fault on the system, the fault current increases leading to a decrease on the power flow along the transmission line and hence, a decrease in bus voltage profile (See Figure 1.6a).

*b) With STATCOM*

During fault condition and with STATCOM installed on the network, the fault current though experiences a swing but in this case, the compensation effect of the STATCOM enhances the power flow on the network as well as the bus voltage profile by damping the swing. This is shown in Figure 1.6b.

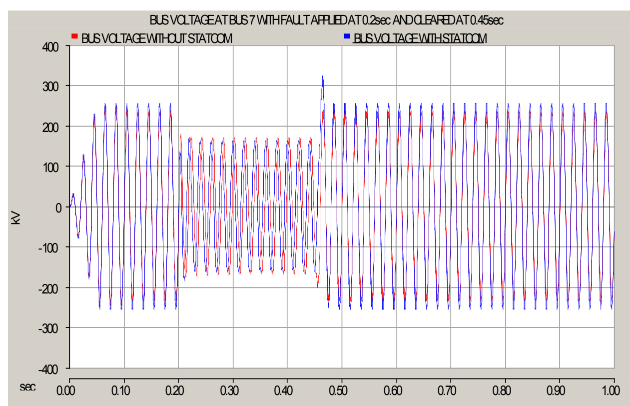



*Figure 1.6a :* Bus Voltage at Bus 6

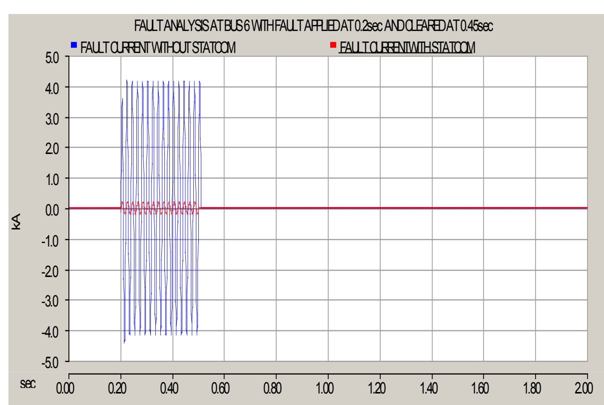



*Figure 1.6b :* Fault Current at Bus 6

## V. Simulation and Results

The ant colony code developed was incorporated and performed on the MATLAB environment; the following results were obtained for various cases.

Also, the algorithm when simulated for the minimum number of iterations required for convergence, finally presents the best results of the optimal bus located by the ant tour and pheromone trail demonstrated graphically in Figures 1.4 and 1.5.

### *a) Case I*

Considering IEEE 14-Bus system, the algorithm is performed with number of bus (Nbus = 13) and converges at the 50th iteration with the optimal bus located at Bus 6. The result of the ant tour and the pheromone trail is demonstrated in Figure 1.4a an Figure 1.4b.

ACO Algorithm MATLAB Display for a 14 Bus System with Optimal Bus as Bus 6.

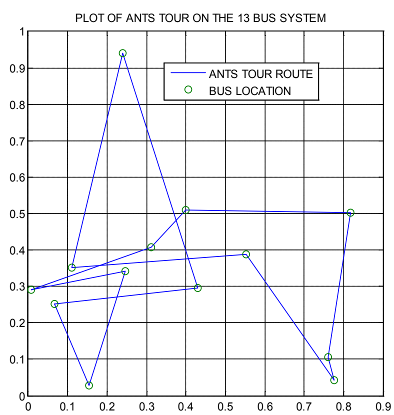



*Figure 1.4a :* Bus 14 Ant tour plot

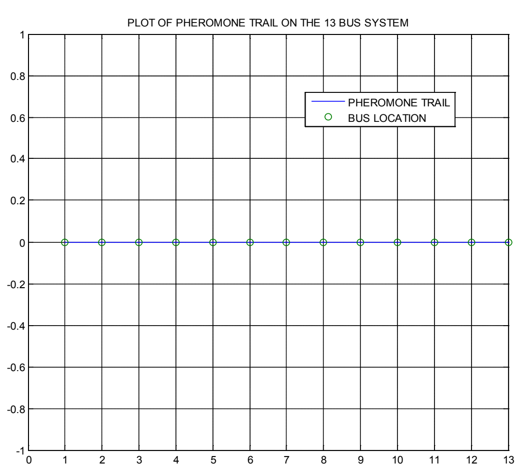



*Figure 1.4b :* Bus 14 Ant Pheromone plot

### *b) Case II*

Considering a Nigerian 30-Bus system, the algorithm is again performed but in this case with number of bus (Nbus = 30) and converges at the 150th iteration with the optimal bus located at Bus 12. The results of the ant tour and the pheromone trail are demonstrated in Figure 1.5a and Figure 1.5b respectively.

ACO Algorithm MATLAB Display for a 30 Bus System with Optimal Bus at Bus 12.

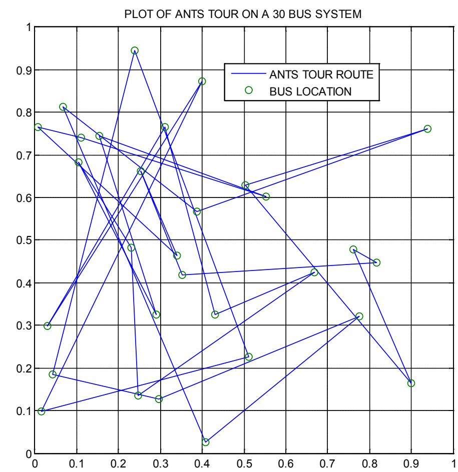



*Figure 1.5a :* Bus 30 Ant tour plot

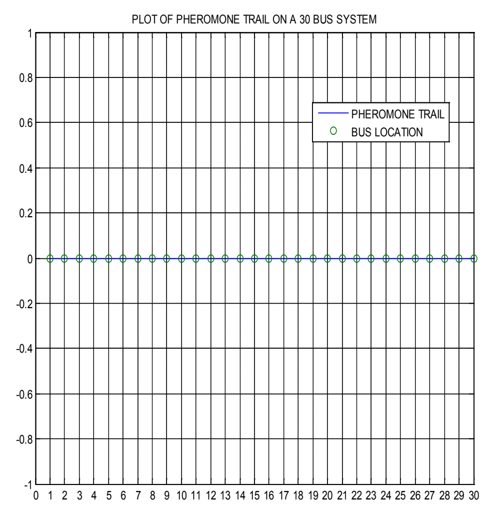



*Figure 1.5b :* Bus 30 Ant Pheromone plot

## VI. Conclusion

In conclusion, this paper has given us a pragmatic approach to STATCOM placement in Nigerian Grid system by Ant colony optimization technique. This can also be used in application to other systems networks outside the scope of this study.

Also, with the optimal placement of STATCOM in a transmission line, most of the bus voltage profiles increase considerably. The optimal placement of the STATCOM is also valid under contingency conditions in both system under study and the IEEE 14- bus systems.

## VII. Appendix

Summary of problem parameters

| | |
|---|---|
| Number of ants | 30 |
| Number of Nodes/Buses | 13 |
| Minimum number of iterations before convergence | 50 |
| Pheromone decay | 5% |
| Pheromone update | 0.21 |
| Total pheromone update | 150 |
| Percentage of visibility | >=95% |

## References Références Referencias

1. Dorigo M, E Banabeau, & G Thereaulaz (2000). Ant algorithms and Stigmergy. Future Generation Computer System. 16: 851-871.
2. Hernandez, M. A. Rodriguez, E. Torres, & P. Eguia (2013). A Review and Comparison of FACTS Optimal Placement for Solving Transmission System Issues. International Conference on Renewal Energy and Power (ICREPQ'13). ISSN 2172-038 X No.11. Bilbao (Spain), 20th to 22nd March, 2013. Pp. 1-6.
3. Khalil, M. R (2008). "Ant Colony Optimization (ACO) Technique for Reactive Power Planning in Power System Stability Assessment", MSc. Thesis, Universiti Teknologi Mara, Shah Alam, Selangor. pp. 1-20.
4. M. Kowsalya, K. K. Ray, & D. P. Kothari. (2009). Positioning of SVC and STATCOM in a Long Transmission Line. *International Journal of Recent Trends in Engineering, Vol 2, No. 5, November 2009.* , Pp. 1-5.
5. Mohd Rozely Kalil, Ismail Musirin, & Muhammad Murtadha Othman (2006). Ant Colony Based Optimization Technique for Voltage Stability Control Proceedings of the 6th WSEAS International Conference on Power Systems, Lisbon, Portugal, September 22-24, 2006. Pp. 149-154.
6. Nwohu, M.N. (2009). Voltage Stability Enhancement of the Nigerian grid system using Flexible Alternating Current Transmission System (FACTS) devices. *PHD thesis. Abubakar Tafawa Balewa University, Bauchi, Nigeria*. Pp. 7-12.
7. Nwohu, M. N. (2010). Optimal Location of Unified Power Flow Controller (UPFC) in Nigerian Grid System using Modified Sensitivity Analysis. Continental Journal of Engineering Sciences, ISSN: 2141 – 4068, Vol. 5(2), pp. 20 – 30.
8. Orihie C. C (2004). 'Problems inherent in the present NEPA grid system'. NEPA, NEWS, ISSN: 0331-3085. July – September publication.
9. S. Bouri, A. Zeblah, A. Ghoraf, S. Hadjeri, & H. Hamdaoui (2005). Ant Colony Optimization to Shunt Capacitor Allocation in Radial Distribution Systems Acta Electrotechnica Et Informatica No. 4, Vol. 5, 2005. Pp. 1-10.
10. Nwohu, M. N. (2011). Effects of Static Synchronous Compensator (STATCOM) on Voltage Stability and Transmission Losses of Electric Power Systems. International Journal of Electrical and Power Engineering, ISSN 1990-7958, Vol. 5(1), pp. 13-17.

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 14 Issue 3 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

# Hazard of Electromagnetic Fields in Biosphere

By Marko S. Markov

*Abstract-* The contemporary conditions of life put the biosphere, in general, and mankind, in particular, to a strong dependence of various physical factors, including electromagnetic fields (EMF). During their phylogenetic and ontogenetic development the living organisms are exposed to various magnetic fields with Earth and space origin. The natural magnetic/electromagnetic fields are characterized with their continuous and comprehensive action throughout the evolution of life on the planet. The beginning of the XXIst century is characterized with exponentially increasing pollution of the atmosphere with various new means of communications which place the entire civilization into uncontrolled action of high frequency electromagnetic fields.

*GJRE-F Classification : FOR Code: 090699*

# Hazard of Electromagnetic Fields in Biosphere

Marko S. Markov

*Abstract-* The contemporary conditions of life put the biosphere, in general, and mankind, in particular, to a strong dependence of various physical factors, including electromagnetic fields (EMF). During their phylogenetic and ontogenetic development the living organisms are exposed to various magnetic fields with Earth and space origin. The natural magnetic/electromagnetic fields are characterized with their continuous and comprehensive action throughout the evolution of life on the planet. The beginning of the XXI[st] century is characterized with exponentially increasing pollution of the atmosphere with various new means of communications which place the entire civilization into uncontrolled action of high frequency electromagnetic fields.

## I. Introduction

The contemporary science has enough evidence that the life originated and developed in the presence of a number of physical factors with terrestrial and space origin including magnetic and electromagnetic fields. One of the most important factors is the Geomagnetic field, formed during the geological evolution of the planet. At the same time, the Earth has been exposed to the influence of ionizing and nonionizing radiation. Due to space limitations, the evolutionary role of magnetic fields will not be a subject of discussion in this paper. However, we will continue our discussion having in consideration the presence in biosphere of natural magnetic and electromagnetic fields.

During the last 120 years the biosphere has been exposed to increasing number and variety of electromagnetic fields related to discovery of industrial methods for generating electricity and further innovations in technology, communication, transportation, home equipment, and education.

More than 45 years ago brilliant Soviet magnetobiologist Yuri Kholodov wrote a book "Man in the magnetic web". (Kholodov, 1976) Long before occurrence of mobile communications, Kholodov pointed out that the entire biosphere is immersed in the ocean of the electromagnetic waves.

During the last quarter of century voices became raised that electromagnetic fields (EMF) might be detrimental for biosphere and human life. After 1976 two serious problems immerged in the public health discussion – potential hazard of low frequency EMF from power and distribution lines (in the late 1970's and 1980's) and mobile communications (mobile phones, Wi-Fi Internet, base stations) that utilize high frequency EMF and represent a serious hazard for public health today. Today the mankind participates in a global experiment conducted by the industry without regulation, rules and control.

The reaction of the American newsmedia, politicians and society to publication of Wertheimer and Leeper (1982) was so strong that in 1992 the Congress of the USA passed Energy Policy Act and dedicated 60 million of dollars for investigation of the potential hazard of electricity for human health. Unfortunately, after 5 years and 41 million dollars spent the conclusion was "we do not have conclusive evidence to link electromagnetic fields to cancer initiation". It would be fair to say that this failure is result of the fact that the project due to the lack of general direction of the research and funding the individual study proposals (it was coordinated by 7 different institutions and had a chairman representative of the society who was never seen before at such meetings).

The hazard of EMF is discussed mainly from the view point of mobile communication and the effects on biosphere are usually neglected. A quarter of century ago, the man-made EMF were named as "factor of new ecology" because of the substantial, even unntoticeable action on the entire biosphere. (Markov, 1988).

## II. Mobile Communications and wifi Tecnologies

I was astonished attending in 1997 the Second World Congress of Electricity and Magnetism to hear from the Chairman Prof. Andersen that in 2010 more than 75% of the World communication will be wireless. It sounded as an unbelievable dream.

However, the industry went even further. By the 2010 in the USA, 285 million mobile phone subscribers have been registered (for a little bit more than 300 million inhabitants). As of August 2013 there were 210 millions cell phone in Brazil (with population of 193 millions). The estimate for the world is more than 5 billion mobile phone users at approximately 7 billion people living on this planet.

Having this in mind, the evaluation and prediction of the potential adverse effects from using wireless communications (any mobile device, including), especially by children, becomes a question of crucial importance. The twenty-first century is marked with exponentially increasing development of technologies that provide wireless communications. To the pollution of the atmosphere with radio and TV signals, not only

*Author:* *Research International, Williamsville NY 14221.*
*e-mail: msmarkov@aol.com*

Global Journal of Researches in Engineering ( F ) Volume XIV Issue III Version I Year 2014
51

satellite communications but also any varieties of the Wi-Fi networks are added.

It is not well known fact that a cellular telephone delivers a power density of radiofrequency radiation about 2 billion times greater than occurs naturally in the environment. Since the mobile phones are designed to operate at the side of the user's head, a large part of the transmitted energy is radiated directly into that person's brain. Therefore, the absorbed energy potentially could cause within the brain dangerous and damaging biological effects. The small cellular telephones effectively deposit large amounts of energy into small areas of the user's head and brain.

The fast development of satellite communications, followed by wireless communications and recently WiFi technology dramatically changes the electromagnetic environment. To continuous action of complex and unknown (by sources, amplitudes, frequencies) electromagnetic fields is exposed entire biosphere and every organism living on this planet. We usually neglect this complex that includes radio and TV transmissions, satellite signals, mobile phones and base stations, wireless communications.

The search for specificity of the WiFi technology can point to the following:

- Popular technology that allows an electronic device to exchange data wirelessly (using RF EMF) over a computer network, including high-speed Internet
- A device that use Wi-Fi can connect to a network resource such as the Internet via a wireless network access point. Such an access point has a range of about 20 meters indoors and a greater range outdoors.

As a result

- Brains of 7,000,000,000 people are exposed to unknown spectrum of EMF
- There is no criteria for hazard levels
- No monitoring
- No research
- No prevention

The fast development of satellite communications, followed by wireless communications and recently Wi-Fi technology dramatically, changes the electromagnetic environment. To continuous action of complex and unknown (by sources, amplitudes, frequencies) electromagnetic fields is exposed entire biosphere and every organism living on this planet. We usually neglect this complex that includes radio and TV transmissions, satellite signals, mobile phones and base stations and wireless communications. (Markov and Grigoriev, 2013).

I want to make clear in the beginning of this paper that my fear from the potential hazard of the mobile communication is related more to the non-thermal effects of this physical factor, unknown to mankind until half a century ago.

Speaking on the potential hazard of Wi-Fi technologies, one should not forget that it includes not only mobile phones but also more importantly all means of emitters and distributors of Wi-Fi signals, mainly antennas, base stations and satellites. In many public locations, own systems are introduced in order to facilitate the work performance. Well, this might be understood. However, why Wi-Fi communications are secured in the subway tunnels? When I was writing this paper, the USA news media are discussing the possibility to allow use of mobile devices during the flight. It obviously requires high and oriented power to which are exposed all passengers in the trains and planes. Just to make comfortable the users of mobile devices. It is forgotten that in the conditions of confined subway tunnels and planes, to use mobile signal significant increase of the delivered power of the signal is needed.

Well, one may agree or disagree with the idea that use of mobile communication devices is hazardous for his health. But the point of hazard for entire biosphere, including humans should not be missed. We are not talking here for the hazard of devices, but for the hazard of means of delivery the signals. It would be plausible to remind once again the words of Kholodov that we exist in the ocean of electromagnetic waves. From newly born baby to the century old gentlemen – everybody is exposed to unknown and frequently changing combination of EMF.

Now, let look what the science is doing in clarifying the situation so important for mankind. The major guidlines established by the engineering community, IEEE (Institute of electrical and electronic engineers) in 2005 and ICNIRP (International commission on non-ionizing protection) in 2009 provide approach and terminology which are not acceptable for physics and biological communities, but nevertheless remain the guiding rules (mainly for the industry). One can only wonder how is possible to speak about potential "health effects" of RF instead of "health hazard". The misuse of the term "health effect" completely neglects the fact that a physical/chemical factor could have either positive (beneficial) or negative (hazard effect). I am suspicious that this is done by purpose not to alarm the general public about the hazard of use microwave radiation in close proximity to the human brain.

It has been pointed elsewhere (Markov, 2006) that the engineering committees statement that "Nonthermal RF biological effects have not been established" basically are guiding science and society into wrong direction. To decline possibility of nonthermal effects is not reasonable, but more important is that they mixed "effect" and "hazard". During the last half a century laboratory and clinical research was performed that indicate the possibility of non-thermal effect, even in greater degree than thermal effects. Israel et al. correctly pointed out that even definition of thermal effect by these international bodies is not accurate. (Israel et al., 2013).

It should be reasonable to mention that this problem is not new. It was noted in 1995 by Kane "Never in human history has there been such a practice as we now encounter with the marketing and distributing of products hostile to the human biological system by an industry with foreknowledge of those effects." (Kane, 1995) What may be added to this powerful statement – R. Kane was high level Motorola executive.

One of the first papers on the absorption of electromagnetic energy was published by Schwan and Piersol, in which they connected this absorption with the tissue composition (Schwan and Piersol, 1954) It is important to note that tissue composition is a very complex one and varies from organ to organ, from person to person. From biophysics point of view the energy absorption also depends on the depth of penetration for the specific frequency range (for 825-845 MHz the penetration depth into brain tissue is from 2 cm to 3.8 cm). (Polk and Postow, 1986).

Fourthy years ago Michaelson (1972) wrote "It should be understood that a cumulative effect is the accumulation of damage resulting from repeated exposures each of which is individually capable of producing some small degree of damage. In other words, a single exposure can result in covert thermal injury, but the incurred damage repairs itself within a sufficient time period, for example hours or days, and therefore is reversible and does not advance to a noticeable permanent, or semi-permanent state. If a second exposure or several repetitive exposures take place at time intervals shorter than that needed for repair, damage can advance to a noticeable stage."

In other words, the repeated irritation of a particular biological area, such as a small region of the brain, can lead to irreparable damage. Given the existence of energy absorption "hot spots" then each damaging exposure to radiofrequency radiation provides a new opportunity that the damage will become permanent. Part of the problem is that an exposed person would never know of the penetration and damage.

Interestingly enough, the basic science from the 1950's to 1990's reported evidence that high frequency EMF can have harmful effects on human organisms and especially on human brain. It has been even detailed in respect of the frequency range: 900-2500 MHz. Number of studies had pointed out that electromagnetic energy in the 900 MHz region may be more harmful because of its greater penetrating capability compared to 2450 MHz, therefore more energy in the 900 MHz frequency range is deposited deeply within biological tissue. In 1976 Lin concluded that 918 MHz energy constitutes a greater health hazard to the human brain than does 2450 MHz energy for a similar incident power density. (Lin, 1976).

It has been reported that diathermy applications consistently show that electromagnetic energy at frequencies near and below 900 MHz is best suited for deep penetration into brain tissue. The depth of penetration is noticeably greater at this frequency range, which includes the portable cellular phone frequencies as compared with higher frequencies. What is also important, it was proven that deep tissue heating is obtained without detecting significant heating in the surface tissues. By their nature the frequencies that provide the best therapeutic heating would also be frequencies that could be most hazardous to man in an uncontrolled situation. High absorption in inner tissue such as the brain occurs while fat and bone absorption is many times less. (Johnson and Guy, 1972).

Let me remind the readers that these studies have been performed and published before mobile communications technologies originated. At once, everybody forget this information. An obvious question arises: If science had developed such knowledge decades ago why today these questions are not at the priority list for research? We would point here two major reasons: The political power of the industry and the failure of the scientific community.

For more than half a century, a very serious group of policy makers and even scientists are playing around the term SAR. The Specific Absorption Rate given in terms of Watts per Kilogram (W/Kg) or milliwatts per gram (mW/g), is assumed to provide a measure of absorbed energy in a given tissue. *Absorption, not delivery.* This term is particularly advantageous for the industry since the energy absorption in biological bodies and specific organs is non uniform and frequency-dependent. However, up today SAR is more often used to describe the energy generated by the source of the electromagnetic field (EMF). One can only wonder how a device may be characterized by SAR. *Let repeat, the specific absorption rate (SAR) identifies the amount of energy that is* ***absorbed*** *in a gram of tissue.*

The inappropriate use of the SAR leads proponents of WiFi technology to affirm that since there is not heating of brain by radiofrequency EMF, there is no hazard for the human brain, completely neglecting the fact that most of biological effects are non-thermal. We are convinced that the safety standards would need to be restated in terms of internal energy absorption.

## III. EMF in Biosphere

Very often the news media discuss how dangerous electromagnetic/magnetic field might be for human health, especially in relation to cancer initiation. The hazard should be considered in respect to the continuous exposure to electromagnetic fields in

Global Journal of Researches in Engineering ( F ) Volume XIV Issue III Version I Year 2014

workplace and/or occupational conditions, while at the same time short, controlled exposure to specific electromagnetic fields makes possible therapeutic benefit.

Concentrating on human health, today science practically neglects the possible ecological effects of RF-EMF. I personally prefer using the term "biosphere" instead "ecology" since it includes not only wild life, but human population, as well. However, it will be used the term ecological for easy understanding the effects in living nature.

Many ecological endpoints (e.g. fertility, reproduction and growth) studied at the level of the individual animal, are crucial from an ecological point of view. It should be pointed that the ecology studies all living organisms, at all organizational levels (i.e. from the smallest molecular system to the largest ecosystem levels). By definition ecology focuses on the higher organizational levels of populations, communities and ecosystems.

This field of research is of crucial importance for the understanding of mechanisms of interaction between complex ecosystems and the environment. (Cucurachi et al, 2012). Animal studies have still been identified as a major research agenda point by the WHO (Van Deventer et al., 2011). The WHO stated that high priority in the field should be given to research on the effects of RF-EMF on development and behavior, on ageing and reproduction of animal subjects. The result of these studies might be ecologically interpreted, because they include ecologically relevant endpoints.

It is important to remember that the entire biosphere exists at "optimal" conditions. This means that when the perturbations in the existing factors (in increase and decrease of the values) could be compensated to certain extent. If, however, the changes are strong enough, the compensation could not be possible.

The most comprehensive review of the lower band MW EMF ecological effects was published by (Cucurachi et al, 2012) using two databases: ISIWeb of Knowledge and Google Scholar. In overall 65% of the studies reported a statistical significant effect of RF-EMF on ecological relevant endpoints. The most represented groups include vertebrates, (predominantly rats, mice and rabbits), then birds and plants. Articles which report significant effects of RF-EMF were found more frequently in the case of birds, insects (i.e. mostly honey bees and fruit flies) and plants.

Interestingly enough, many studies on birds were performed in the laboratory. Amongst the more recent laboratory studies, evidence of an effect of RF-EMF on mortality and development of embryos was in all cases found at both high and low dosages. In al field studies was found a significant effect of RF-EMF on breeding density, reproduction or species composition.

The animal systems commonly used in laboratory studies include rats (Wistar albino rat and Sprague Dawley rat), mice (Balb/c and Balb/c/f), rabbits (White New Zealand Rabbit), rhesus monkeys (Macaca mulatta). A total of 27 experiments (43%) showed no significant results of an impact of RF-EMF under the physical and experimental settings used. The power density ranged from $0.6\times10-6$ to 20 mW/cm$^2$, which was the maximum value measured for MW CW exposures.

A large share of the studies on vertebrate animal models focused on changes in behavior as a result of exposure. This choice may be related to investigating of possible influences of RF-EMF on the behavior and cognitive performance of humans, who use mobile phone devices in close proximity to their heads. Some commonalities between human and rat response to noxious substances have been explored by other fields of science. Lai et al. (1994) suggested that rats suffer from a deficit in spatial working memory function when exposed to RF-EMF (50% decreased performance compared to control).

The articles by Lee et al. (2009, 2012) and Imai et al. (2011) are the only studies focusing on the impact of the frequencies network standards found in 3G mobile communication (Collins and Smith, 2001), working with protocols like wideband code division multiple access (W-CDMA) or CDMA. All experiments, on mice and rats, did not have any observable adverse effect on development, reproduction or mutation of tested subjects. These studies represent the first attempt to investigate the effects of wireless communication on health.

The influence of the earth's natural magnetic field or that of superimposed artificial magnetic fields on plants has been known for many years. Static magnetic fields, in fact, have been proven to have a beneficial impact on the stimulation of growth and germination of plants (Dulbinskaya, 1973; Pittman, 1965; Savostin, 1930), or inhibitive impact depending on the species and their physiological state (Krizaj and Valencic, 1989). According to Soltani et al. (2006), until now no proper physiological explanation has been provided for the described effects, though the biological effects of weak static MF do not depend only on the physical conditions of the exposure, but also on the environmental conditions in place.

In most of the field studies information for the values of local magnetic field(s) is missing. One anecdotal example might be found in experience from former Soviet Union: It was decided to bring in the area of Kursk corn from Kazaxstan know with higher yield. However, the yield in new place failed in 50%. Nobody paid attention that in Kursk the value of geomagnetic field was 2 Gauss, while in Kazaxstan only 0.5 Gauss. When returned back, the seed slowly (within 3 years) returned to previous yield.

Probably here I should mention the report of Pavlovich(1976) who place in a mu-metal container a colony of microorganisms with 24 hours reproduction cycle. At day 7 he observed mutation in the culture. The reason? This container shields the colony from ambient magnetic field. Several generations grew in conditions of absence of usual magnetic field and started to search for accommodation to new condition and find this way in mutation.

The analyzed literature considered that plants are continuously exposed to RF-EMF as they cannot avoid them, by moving away from the source of emission. In total, 16 studies and 29 experiments were selected by Cucurachi et al. (2012) based on the ecological relevance of the endpoints studied.

The frequency investigated ranged from as low as 10 MHz to 2450 MHz with power density from 0.015 mW/cm$^2$ to 50 mW/cm$^2$. A Latvian group of researchers (Balodis et al., 1996; Magone, 1996; Selga and Selga, 1996) focused on the area of Skundra, Latvia, where a radio location station had been operating for 20 years. The three studies provide a unique experience of a complete set of experiments and field studies conducted around a radio station in the short as well as in the long term. The studies also assessed RF-EMF effects at different distances from the station. As a result, the non-thermal RF-EMF under investigation indicated that the effects of short term exposure (i.e. up to five days) are dependent on the stage of growth of great duckweed at the time of exposure.

The vegetative growth of young plants decreased as a consequence of exposure, while it even accelerated in the case of older plants. The exposed population of adult plants was on average growing 150% more than the control unexposed samples. The effects of RF-EMF emitted by the radio station were analyzed using retrospective tree ring data in Balodis et al. (1996): a significant negative correlation between the measured electric field at specific sample locations and the mean relative additional annual increment of pines has been identified. Selga and Selga (1996) found significant cytological and ultra-structural changes in exposed pine needles and cones.

A connection between exposure and very rapid molecular stress responses was made in the studies performed by Roux et al. (2006, 2008) focusing on the molecular responses of tomato plants. The study was based on the use of several stress related transcripts (e.g. energy charge and protease inhibitor). Great differences were found in the exposed population compared to the control (up to 300%). The data supports the evidence that plants respond to exposure as they would respond to any other injurious treatment. Even though the RF-EMF used was non-thermal and the total power used was low, results, as the authors commented, are strikingly similar to those found when plants are wounded, cut or burned.

To summarize: The number of studies finding effects was highest for plants (90%) and insects (90%), lower for birds (70%), other vertebrates (56%) and other organisms (50%). In all the available field studies significant effects of RF-EMF were found. In laboratory experiments, birds and vertebrate animal subjects were in most cases tested at higher frequencies than smaller organisms (e.g. fruit flies) and plants.

One serious obstacle in evaluating effects of EMF in biosphere and even in laboratory is insuficiant reporting of the parameters of the study which makes difficult, if not impossible to compare results from different studies. Some studies only provided the frequencies of the RF-EMF emitting device and one dosage parameter (e.g. power density in mW/cm2). A limited number of studies supplied the full list of physical parameters needed for an adequate description of the exposure (e.g. modulation, spatial connotation of field, polarization, field pattern and measuring techniques). The reporting of the measured or extrapolated power density values and relative electric field values were discordant and no precise information was given on measurement or calculation procedures. Also relevant biological parameters such as size of the target, tissue dielectric properties, geometry, and relation to polarization are often neglected. In a critical review of 56 reports, Colbert et al. (2008) found that only 2 papers correctly explained 10 parameters of the exposure.

The ICNIRP guidelines (1998, 2010) provide limiting values as basic restrictions and reference levels for the exposure of humans to RF-EMF. These guidelines have been adopted by most European countries which have imposed limits (EU Commission implantation Reports, 2008). There are currently no guidelines for the exposure of biodiversity to RF-EMF. The available data has so far been inadequate to judge whether the ICNIRP guidelines and other environmental standards should be the same or significantly different from those appropriate to protect human health.

No clear relationships, in fact, could be declared between dosage and effects because of a wide variety of exposure strengths, durations, conditions, frequencies, time between exposures, assessment methods, measurement systems, replications efforts, and adequate dosimetry. Some authors consider that in the older laboratory studies the interpretation of results needs to be filtered by the consideration of a lack of control of temperature. In the other studies the balance of experimental evidence points towards a non-thermal effect of RF-EMF exposure.

At the current state of our knowledge, there is an urgent need for repetitions of experiments and field studies by other research groups in order to confirm the presence/absence of effects. ICNIRP statement of (2010), suggests that results can only be accepted 'for health risk assessment if a complete description of the experimental technique and dosimetry are provided, all data are fully analyzed and completely objective, results show a high level of statistical significance, are quantifiable and susceptible to independent confirmation, and the same effects can be reproduced by independent laboratories' (Repacholi and Cardis, 1997).

Experiments evaluating the impact of newer wireless technologies (e.g. WiMAX, WLAN and WiFi), together with studies analyzing new generations of mobile phone technologies (e.g. 3G and 4G) would shade some light on the impact of these technologies for ecosystems. To our knowledge solely the study on mice by Lee et al. (2009) investigated the possible impacts of these technologies. In order to minimize the uncertainties as efficiently as possible a number of situations with limited number of studies should be investigated: the long-term monitoring of selected species and/or ecosystems, field studies under a controlled system of exposure, laboratory studies following given recommendations, and studies on important ecological groups, other than those here analyzed, would be a solid base on which to focus future studies.

The physical parameters usually reported regarded the measured level of power flux density and specific absorption rate (SAR). These parameters were either measured using probes or specific detectors or were based on the information of the manufacturers of the exposure devices. All the reported physical parameters varied greatly across studies. The estimated SARs ranged between 0.001 W/kg and 140 W/kg. I wonder what actually means "estimated SAR". Let me point that SAR means specific absorption rate. In other words this is characteristic of the specific absorption of the energy in the target tissue or organ. Since biological systems are effectively non-linear systems it is hard to accept that the term "estimated SAR" represents a term to be believed.

SAR was introduced as an attempt to evaluate the energy deposition in a given tissue with the presumption that the RF effects are only thermal. This definitely leads in wrong direction, since plenty of studies demonstrated non-thermal character of interactions between RF EMF and living tissues.

## IV. Electromagnetic Hypersensitivity (EHS)

There is a small fraction of human population that is supersensitive to exposure to EMF. Even having in mind that it is 1-3% of population, it is important that public health system take care for these people. On the other hand, studying the adverse reactions of these people, scientists might pay more serious attention to entire civilization. This problem is real, the attitude of science and industry – not. What the science says: "The symptoms are real, but what causes them is a mystery". The industry is even more severe: "It is just psychology, nothing is real". The same mantra is propagated by WHO, ICNIRP and numerous expert committees. Dr. Darius Lezchinsky (private communication) wrote: "I have the feeling that this mantra was introduced to the EMF research area few years ago for the sole purpose to "get the EHS people off our backs". Designers of this mantra assumed that by showing compassion for the suffering of EHS people they will alleviate tensions that exist between EHS sufferers and decision-makers."

Let discuss here the problem of identifying the EHS and helping the victims. First of all, EHS is not a well defined ailment. The list of symptoms claimed to be caused by EMF is long and very unspecific. The same symptoms can be caused by a variety of factors, including simple, life accompanying, stress. Distinguishing which stressor is responsible for EHS symptoms might be challenging even for well trained general practitioners. Therefore, patients are referred to psychologists and psychiatrists. This leads to generation of research studies that by design are unable to detect EHS. Using methods of psychology or psychiatry will not answer whether biochemically physiology of our body is affected by the exposure to EMF.

Unfortunately, the diagnosis of EHS is difficult because we all are exposed to enormous variety of EMF that surround every living creature. It is not only wireless communication-emitted radiation, but a whole range of professional utilities and home appliances. It will be fair to say that we are surrounded by the ocean of EMF with different amplitudes, frequencies and duration of action. Due to increasing development of new and new means and devices for WiFi communications, the entire world population is participating in a global "experiment: without control and protocol of the study. (Markov and Grigoriev).

Since we do not know what might be the physical parameters of exposure that triggers EHS symptoms it is difficult to identify the specific EMF source that causes the problem. But this should not be the reason to claim the lack of causality between EHS and EMF. The existence of EHS is a simple fact of life. The only question is what exposure parameters are sufficient to trigger EHS. For every radiation type, every chemical, every environmental pollutant there exist sub-populations of people who are more sensitive than others. This phenomenon, known as individual sensitivity, is encoded in our genetic diversity. Ironically, the only case where the individual sensitivity is denied is when it affects the interests of the wireless communications industry.

## V. Recent Development

At the end of March 2014 The European Commission organized a workshop in Athens, Greece on EMF electromagnetic fields and health effects focused on public awareness, conciliating scientific findings and uncertainties in policy making. The event included presentations from various parties from the European Commission, WHO, public authorities, industry, operators, environmental and consumer associations and academia. The goal of the conference was to reach a common approach for the future in order to respond to public concerns about electromagnetic fields, to enhance information dissemination and discuss new studies and scientific evidence in relation to EMF, and to identify knowledge gaps needed for sound policy making. In this context, the new SCENIHR draft opinion on EMF and potential health effects was presented. SCENIHR, the Scientific Committee on Emerging and Newly Identified Health Risks, has been charged with providing reports for the European Commission and Members of the European Parliament which may be relied upon by all participating governments. Furthermore the 500 million citizens of Europe are relying on SCENIHR's review.

Unfortunately, SCENIHR's review clearly cherry picked their own research and promoted it as gold standard while heavily criticizing Lennart Hardell's research." The Hardell Group published five ground breaking studies in 2013, that are the first to correlate mobile phone usage with incidences of brain tumors over a 20+year period of time, longer than any other epidemiological studies. They found a clear correlation between cell phone usage and two types of brain tumors, acoustic neuromas and the deadliest of all brain cancers, gliomas. While the Hardell's studies have been accepted prior to 2013, including taking into consideration when the IARC scientists almost unanimously voted for the 2B "possible carcinogen to humans" classification for the entire RF EMF Spectrum, now situation changes. In my opinion it happened after the long delay of the final report of the INTERPHONE multinational study leads to separation of the participants in the project into two groups. One may wonder how the multiyear project that supposed to be conducted under same protocol can lead to completely different opinions.

The scientific dispute brings to the scene the highest court in Italy which favoured Hardell's position over the 2010 Interphone Studies, considering Hardell's studies more reliable and independent than the Interphone study which had been part funded by the mobile phone industry.

Moreover, Paolo Rossi, Italian Ministry of Health said, "Children should not use mobile phones as a toy". I completely agree with such position. Unfortunately, while mobile phones were a tool for communication a decade ago, now the different WiFi items might be seen in the hands of children as young as 3 years.

For years scientists have been offering incomplete, inconsistent and contradictory information, leading to confusion for the public and policy makers, resulting in members of the public seeking justice via the courts. "There is a lack of responsibility taken with policy makers saying they are relying on government and industry funded scientific reports from scientists. Then these same scientists say it is the duty of policy makers to protect public health. At the same time, important reports fail to do a thorough review of literature on non-ionizing electromagnetic fields (EMF) and biological health effects. Only selected papers were evaluated using ambiguous criteria. Most of the following publications since 2007 were not considered by SCENIHR.

*a) Genetic Effects*

- RFR: 114 papers (65% reported effects)
- ELF EMF: 59 papers (83% reported effects)

*b) Neurological Effects*

- RFR: 211 papers (68% reported effects)
- ELF EMF: 105 papers (90% reported effects)

*c) Oxidative Status*

- RFR: 106 papers (88% reported effects)
- ELF EMF: 110 papers (88% reported effects)

Lai and Levitt said, "It is outrageous to ignore any effect of EMF exposure on human health and a crime to humanity not to recommend any action to curtail the exposure."

"The world urgently needs to be informed that these five papers by the esteemed Hardell Group were dismissed and ignored by Schüz, by IARC, by WHO, and as we witnessed in Athens, by SCENIHR," Eileen O'Connor stated. "These papers have been placed directly into the hands of the EU Commission along with the report from Lai and Levitt outlining hundreds of missing research papers demonstrating positive results in the hope that policy makers can hold SCENIHR accountable."

She said "'Failure is not an option.' These are the famous words from the Apollo 13 control room chief officer Gene Kranz and these words have followed me since meeting him in 1999." The rocket scientist continued, "Our European Community is being irradiated by microwaves; people are becoming ill and suffering with many conditions including electrosensitivity. The World Health Organization has also declared a possible correlation to cancer in humans. It's not rocket science. It's just common sense and sound science."

Eileen O'Connor stated: "*As of March 28, 2014 representatives of the telecom industry, government officials, and WHO scientists absolutely, irrefutably have the latest science from Hardell and know that Hardell himself is calling for RF to be classified a Group 1 carcinogen. The clock has now started ticking on liability. No more excuses. SCENIHR, The industry, the*

Global Journal of Researches in Engineering ( F ) Volume XIV Issue III Version I Year 2014

*EU Commission, and WHO are now fully informed.*" Once adopted, this opinion will update previous Scientific Committee opinions of 19 January 2009 and 6 July 2009 in light of newly available information.

## VI. Precautionary Principle

Generally speaking, we do not know if or to which extent the WiFi radiation alters physiology of normal, healthy organisms. The situation became more complex when we are asking about the influence on children, on aging adults or sick individuals.

Every evaluation of the "hazard" as well as every standard for the permissible level of exposure should be done following the precautionary principle: If we do not know that a given food, drink, medication, physical, or chemical factor is safe, we should treat it as potentially hazardous.

If this approach is applicable in so many areas of life, in production of food and drinks, in approval of medications, why it is not applied in the EMF generating devices? My own explanation is that the regulatory organs neglected the potential hazard of exposure to EMF of living creatures – from microorganisms to elephants, to humans.

The hazard issue is frequently represented as "controversial", and it is absolutely incorrect. It is not controversial issue, it is conflict of interest of industry on one side and mankind and environment on the other.

It is remarkable that IARC (International Agency of Research on Cancer) in the summer of 2011 classified radiofrequency electromagnetic fields as possible cancerogene.

It is not too late yet to recognize the potential hazard from electromagnetic fields acting in biosphere and especially on the human population. Scientists and policy makers should recognize that especially with development of satellite and wireless communication, all living creatures in the biosphere are exposed to continuous action of electromagnetic fields.

## References Références Referencias


1. Balodis VG, Brumelis K, Kalviskis O, Nikodemus D, Tjarve VZ. Does the Skrundra radio location station diminish the radial growth of pine trees? Sci Total Environ 1996;180: 57–64.
2. Colbert AP, Markov MS, Souder JS (2008) Static magnetic field therapy: Dosimetry considerations. J Altern Complim Med 14: 577-582.
3. Collins D, Smith C. (2001) 3G Wireless Networks. McGraw-Hill.
4. Cucurachi S, Tamis WLM, Vijver MG, Peijnenburg WJGM, Bolte JFB, de Snoo GR (2012) A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF). Environment International 51 (2013) 116–140.
5. Dulbinskaya DA (1973)Effect of constant magnetic field on growth of maize seedlings. Fiziol Rast 1973;20(1):183–6.
6. EU (2011) The potential dangers of electromagnetic fields and their effect on the environment report of the committee on the Environment, Agriculture and Local and Regional Affairs. available online at http://assembly.coe.int/documents/workingdocs/doc11/edoc12608.pdf. [last accessed 18 April 2012].
7. ICNIRP (International Commission on Non-ionising Radiation Protection) (2010). Statement guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (1 Hz–100 kHz). Health Phys 99:818–36.
8. ICNIRP (1998) (International Commission on Non-Ionizing Radiation Protection). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Phys 74(4):494–522.
9. Imai N, Kawabe M, Hikage T, Nojima T, Takahashi S, Shirai T (2011) Effects on rat testis of 1.95-GHz W-CDMA for IMT-2000 cellular phones. Syst Biol Reprod Med 57(4):204–9.
10. Israel M, Zaryabova V, Ivanova M (2013). Electromagnetic field occupational exposure. Non-thermal vs. thermal effects. Electromagn Biolo Med 32: 145-154.
11. Johnson CC, Guy AW (1972) Nonionizing electromagnetic wave effects in biological materials and systems. Proceedings IEEE, 60 #6 692-718
12. Kane R (1995). Cellular telephone Russian roulette. New York: Vantage Press, Inc. p 241.
13. Kholodov YA. (1976). Man in magnetic web. Moscow: Nauka (in Russian).
14. Krizaj D, Valencic V (1989) The effect of ELF magnetic fields and temperature on differential plant growth. J Bioelec 8(2):159–65.
15. Lai H, Horita A, Guy AW (1994) Microwave irradiation affects radial-arm maze performance in the rat. Bioelectromagnetics 15:95-104.
16. Lee HJ, Lee JS, Pack JK, Choi HD, Kim N, Kim SH, et al. (2009) Lack of teratogenicity after combined exposure of pregnant mice to CDMA and WCDMA radiofrequency electromagnetic fields. Radiat Res 172(5):648–52.
17. Lee HJ, Jin YB, Kim TH, Pack JK, Kim N, Choi HD, et al. (2012) The effects of simultaneous combined exposure to CDMA and WCDMA electromagnetic fields on rat testicular function. Bioelectromagnetics 33(4):356–64.
18. Lin JC (1976). Interaction of two cross-polarized electromagnetic waves with mammalian cranial structures. IEEE Trans Biomed Eng BME 23(5): 371–375.
19. Magone I. The effect of electromagnetic radiation from the Skrunda Radio Location Station on

Spirodela polyrhiza (L.) Schleiden cultures. Sci Total Environ 1996;180: 75–80.
20. Markov MS (1988) Electromagnetic fields – a new ecological factor. In Markov M and Blank M (Eds) Electromagnetic fields and biomembranes. Plenum Press, NY 135-140.
21. Markov M (2006) Thermal vs. nonthermal mechanisms of interactions between electromagnetic fields and biological systems. In Ayrapetyan S and Markov M (Eds.) Bioelectromagnetics: Current concepts 1-16.
22. Markov MS, Grigoriev YG. (2013) WiFi technology – an uncontrolled experiment on human health. Electromagnetic Biology and Medicine 32 (2).
23. Michaelson SM (1972). Human exposure to nonionizing radiant energy – potential hazards and safety standard's. Proceedings of the IEEE 1: 389–421.
24. Pavlovich SA. (1975). Shielding magnetic fields may cause mutations in microorganisms. Nauka, Moscow,. (in Russian).
25. Pittman UJ (1965) Magnetism and plant growth. Effect on germination and early growth of corn and beans. Can J Plant Sci 1965;45:549–55.
26. Polk C, Postow E, editors. (1986). CRC handbook of biological effects of electromagnetic fields. Boca Raton, FL: CRC Press.
27. Repacholi MH, Cardis E (1997) Criteria for EMF health risk assessment. Radiat Prot Dosim 72: 305–12.
28. Roux D, Vian A, Girard S, Bonnet P, Paladian F, Davies E, et al. (2006) Electromagnetic fields (900 MHz) evoke consistent molecular responses in tomato plants. Physiol Plant 128:283–288.
29. Roux D, Vian A, Girard S, Bonnet P, Paladian F, Davies E, et al. (2007) High frequency (900 MHz) low amplitude (5 V m−1) electromagnetic field: a genuine environmental stimulus that affects transcription, translation, calcium and energy charge in tomato. Planta 227:883–891.
30. Savostin PW (1930) Magnetic growth relations in plants. Planta 12:327.
31. Selga T, Selga M (1996) Response of Pinus sylvestris L. needles to electromagnetic fields. Cytological and ultra-structural aspects. Sci Total Environ 180:65–73.
32. Schwan HP, Piersol GM (1954). The absorption of electromagnetic energy in body tissues. Int Rev Phys Med Rehabil 33(6):371–404.
33. Soltani F, Kashi A, Arghavani M (2006) Effect of magnetic field on Asparagus originalis L seed germinaton and seedling growth. Seed Sci Technol 2006;34 (2):349–53.
34. Van Deventer E, van Rongen E, Saunders R (2011) WHO research agenda for radiofrequency fields. Bioelectromagnetics 2011;32:417–42.
35. Wertheimer N, Leeper E (1982) Electrical wiring configuration and childhood cancer. Am J Epidemiol 109: 273-284.

This page is intentionally left blank

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 14 Issue 3 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

# Fault Analysis and Electrical Protection of Distribution Transformers

By Md Asaduzzaman Nur, Mehdi Hasan Sourov, M. S. Muhit & Md Khaled Hossain

*American International University, Bangladesh*

*Abstract-* The demand on the electric power for the household, commercial and industrial loads is on the increase. Also, the management of electric distribution system is becoming more complex. Lack of information at the base station regarding status of the distribution network has been identified as the major bottleneck to its effective monitoring and control. The work described is a development of Microcontroller-based Protection of Electric Distribution system for the purpose of effective monitoring and control of distribution system. A powerful GSM networking is designed to send data from Distribution side to the Sub-station and a Matlab GUI system has been develop to show the data. In general, the proposed design is developed for the user to easily recognize the distribution transformer is safe or unsafe and the distribution line that is suffered by fault. The ultimate objective is to monitor the distribution line status continuously and hence to guard the fault of distribution line due to the constraints such as overvoltage, under voltage, SLG, DLG faults. If any of these does occurs then a message will be sent to the designed controlling unit or substation.

*Keywords: microcontroller, transformer protection, GSM module, GUI, bridge rectifier, wireless monitoring & control.*

*GJRE-F Classification : FOR Code: 290901p*

# Fault Analysis and Electrical Protection of Distribution Transformers

Md Asaduzzaman Nur [α], Mehdi Hasan Sourov [σ], M. S. Muhit [ρ] & Md Khaled Hossain [ω]

*Abstract-* The demand on the electric power for the household, commercial and industrial loads is on the increase. Also, the management of electric distribution system is becoming more complex. Lack of information at the base station regarding status of the distribution network has been identified as the major bottleneck to its effective monitoring and control. The work described is a development of Microcontroller-based Protection of Electric Distribution system for the purpose of effective monitoring and control of distribution system. A powerful GSM networking is designed to send data from Distribution side to the Sub-station and a Matlab GUI system has been develop to show the data. In general, the proposed design is developed for the user to easily recognize the distribution transformer is safe or unsafe and the distribution line that is suffered by fault. The ultimate objective is to monitor the distribution line status continuously and hence to guard the fault of distribution line due to the constraints such as overvoltage, under voltage, SLG, DLG faults. If any of these does occurs then a message will be sent to the designed controlling unit or substation.

*Keywords: microcontroller, transformer protection, GSM module, GUI, bridge rectifier, wireless monitoring & control.*

## I. Introduction

Protection system's main function is to clear faults from the power system at high speed to ensure safety, minimize equipment damage and maintain power system stability[2]. Protection of power systems requires an understanding of system faults, their detection, and safe isolation of the faulted device. By taking an inventory of all the essential electrical loads and doing a basic electrical load evaluation [2], an idea regarding how much power our system needs to produce has been obtained. We are also aware about the power fluctuation situations also that means what voltage minimum / maximum we are getting from the A.C supply mains. In doing this project we would be using concepts of microcontrollers, GSM network and GUI of MATLAB.

## II. Fault Types and Protection

### *a) Single-Line-to-Ground Fault*

A short circuit between one line and ground, very often caused by physical contact, for example due to lightning or other common means. The single line to ground fault can occur in any of the three phases [1]. However, it is sufficient to analyze only one of the cases.

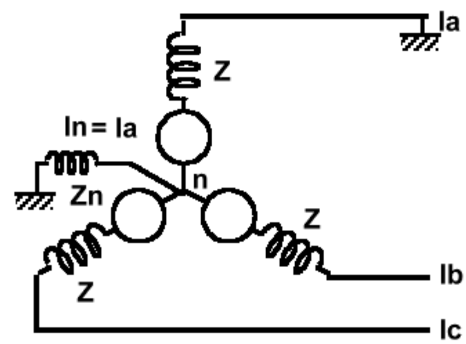



*Figure 1 :* Single Line to Ground fault

### *b) Line-to-Line Fault*

A short circuit between lines, caused by ionization of air, or when lines come into physical contact[1], for example due to a broken insulator. For a Line-to-line fault, the currents will be high, because the fault current is only limited by the inherent (natural) series impedance of the power system up to the point of faulty (refer Ohms law).

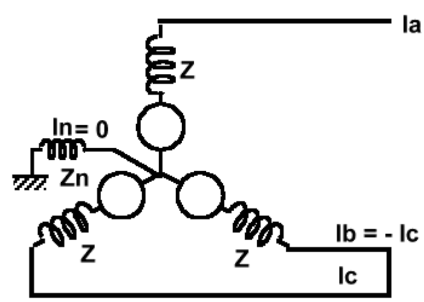



*Figure 2 :* Line to line fault

### *c) Double-Line-to Ground Fault*

Two lines come into contact with the ground (and each other), also commonly due to stormy weather or some other means [1].

*Author α σ ω: Student, Electrical and Electronic engineering department, AIUB, Dhaka, Bangladesh 1.*
*e-mail: nur.aiub@yahoo.com*
*Author ρ: Faculty, Electrical and Electronic engineering department, AIUB, Dhaka, Bangladesh 3.*

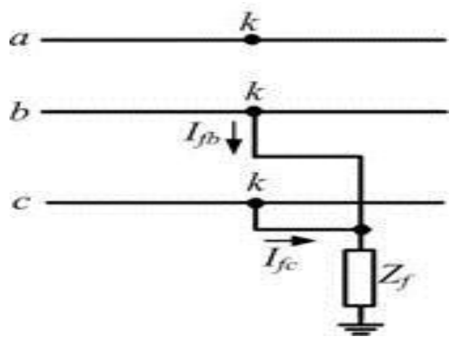



*Figure 3 :* Double line to Ground Fault

*d) Transformer Protection*

Transformers are a critical and expensive component of the power system. Due to the long lead time for repair of and replacement of transformers, a major goal of transformer protection will restrict the damage to a faulted transformer & also protect it from thieves to avoid long term area blackouts. The comprehensive transformer protection provided by multiple function protective relays is appropriate for critical transformers of all applications [2]. Organized theft of electric transformers from live transmission lines is widespread throughout the country making power distribution agencies and consumers counting losses in several millions of BDT and great sufferings. In the last 10 years, electric transformers worth BDT 2000 Million had been stolen. So, for an improved power system stability and efficiently innovative technology, a micro controller based protection system should be achieved to protect transformers.

*e) Lower Voltage*

Low voltage is a relative term, the definition varying by context. Different definitions are used in transmission and distribution line, and in the electronics industry. Electrical safety codes define "low voltage" circuits that are exempt from the protection required at higher voltages. These definitions vary by country and specific code. Lower voltage is defined as incoming line voltage at the point of use which is smaller than the Public Service Commission's mandated legal limits; and/or smaller than the voltage ratings of the connected equipment. Lower voltage is considered a safety hazard by all industry standards and can cause premature failure of connected equipment. Devices could be damaged by lower line voltage.

*f) Over Voltage*

Overvoltage is defined as incoming line voltage at the point of use which is greater than the Public Service Commission's mandated legal limits; and/or greater than the voltage ratings of the connected equipment. Overvoltage is considered a safety hazard by all industry standards, and can cause premature failure of connected equipment. Overvoltage has been a widely known industry problem for many years, but it is not generally understood by many who have to deal with it. Power companies have been unable to control it adequately. Overvoltage occurs most often during severe cold winter weather for the following reasons: (1) Inadequate size of power distribution systems; (2) slow reaction time for power company's distribution systems to regulate voltage during extreme load variations; and (3) abrupt reductions of loads

## III. Block Diagram Arrangement

In figure 4, the basic arrangement of the implemented project can be found.

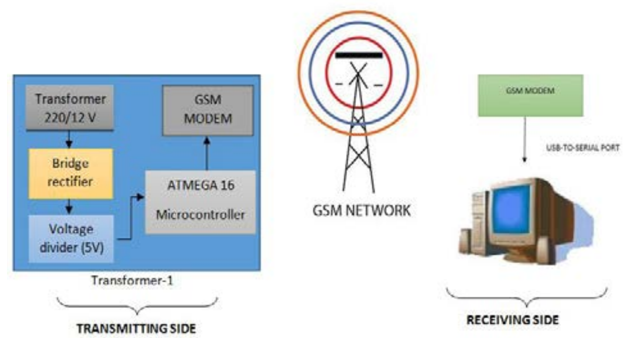



*Figure 4 :* Block diagram arrangement of the project

Among the major components required to establish the project, few of them are the power transformers (step down), microcontroller ATMEGA 16 and GSM module, Bridge rectifier.

*a) Transformer*

Transformer is an electrical device used to step up and down the AC voltages. There are two types of transformers: Step up and step down transformer. Step up transformer increases the magnitude of voltage while step down transformer decrease the magnitude of voltage. Depending on the ratio of the number of turns in the primary & secondary winding a transformer is characterized as step up or step down. For this project purpose, considering 1Φ voltage to be around 220 V, 3 step down power transformer of rating 220/12 has been used to represent a realistic representation of the 3 Φ system.

*Figure 5 :* 220v/12v transformer

*b) Microcontroller ATMEGA 16*

Brain of this project is Atmega16 micro-controller. It is a 8 bit Micro controller with RISC architecture. Its speed is up to 16MIPS throughput at 16MHz. It has 16K bytes of flash and 512 bytes EEPROM. Operating voltage 2.7v -5.5v, in active mode it consumes only 1.1mA & in sleep mode it consumes less than 1uA current which made it a perfect choice for his project [3].

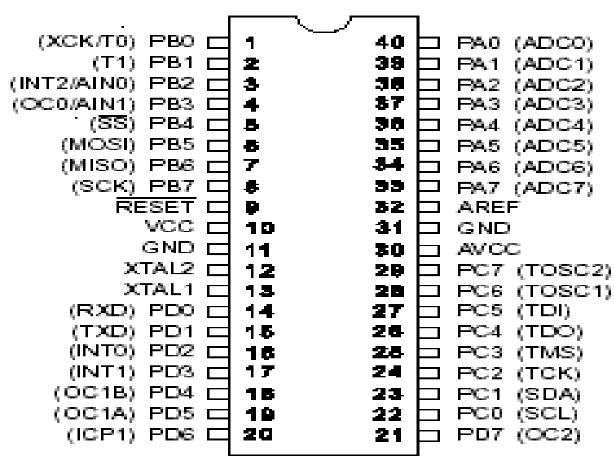



*Figure 6 :* Atmega16 microcontroller

*c) GSM Module*

Sim900 has been used as GSM module. SIM900 module is a complete Quad-Band GSM/GPRS module which combines GPS technology for satellite navigation. The compact design which integrated GPRS and GPS in a SMT package will significantly save both time and costs. Power consumption (GSM engine in sleep mode) around 1.5mA and Power consumption (GSM engine in idle mode) around 77mA [4].

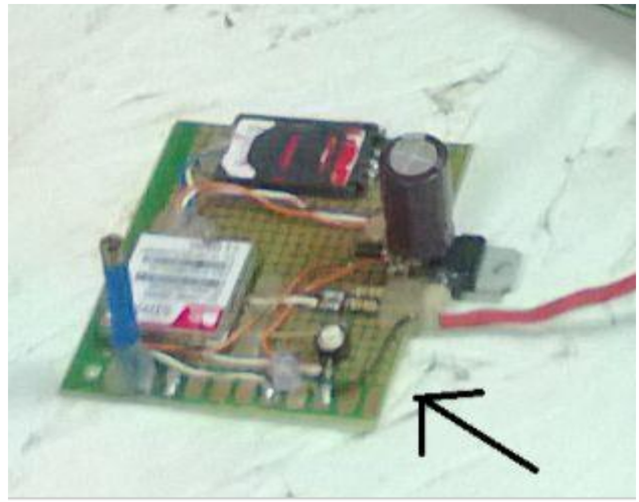


*Figure 7 :* GSM module Sim900

*d) Bridge Rectifier*

An AC power source is required for powering major appliances but almost all electronic circuits require a steady DC supply. A simple rectifier circuit described in this project converts the input from AC source to DC voltage. Firstly, the AC input from mains is stepped down to a lower value of voltage. This AC supply is then passed through a rectifier circuit to remove the negative cycle of AC waveform. The resulting signal is then filtered to get the DC output. The major part of the circuit is connected to the secondary coil of the transformer which is comprised by diodes and capacitor. While the diodes act as a rectifiers, capacitor filters out the DC component from the circuit.

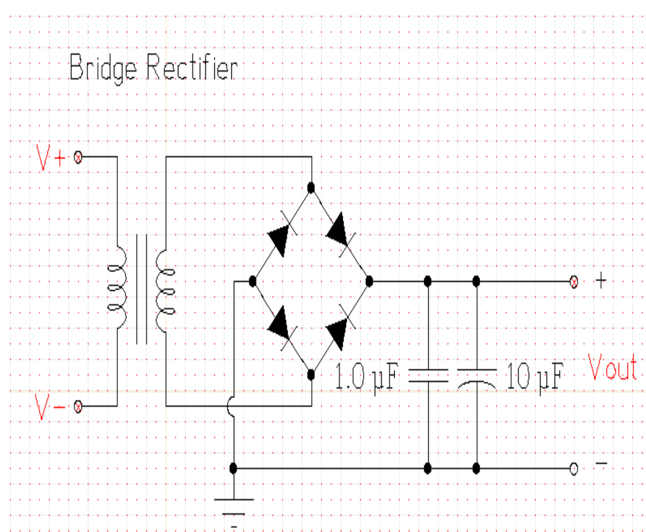



*Figure 8 :* Bridge rectifier

## IV. Simulation

The initial stage, the circuits have been designed and simulated in PROTEUS. The circuit have been utilized to analyze the line to line, single line to ground, double line to ground, open conductor, over voltage and under voltage in the sides of the transformer. The circuit diagram can be found in figure 9.

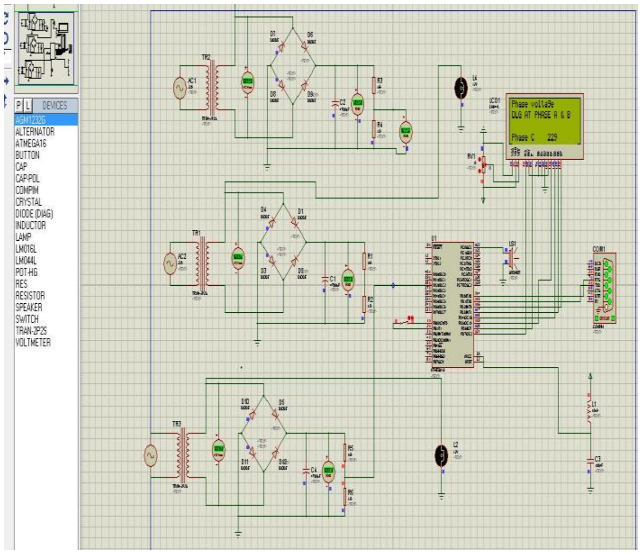


*Figure 9 :* Circuit Simulation

## V. Hardware Implementation

In reference to figure 4, the transmitting and receiving side can be described as follows:

### a) *Transmitting Side*

Heart of the project is the microcontroller ATMEGA 16. In general the normal distribution phase voltage is 220 V, in this project we used a step down transformer 220/12 V for converting the phase voltage from 220 V to 12 V. Then, a bridge rectifier has been used for converting the 12 V ac to 12 V dc; after that, applied voltage divider converts the 12 V to 5 V because the microcontroller works at maximum 5 V. By this process the three distribution phase is connected into three microcontroller pins and the power transformer is connected by a narrow wire between 2 pins of the microcontroller. At cases, when the distribution side is in load shedding protection of transformer must be ensured, which is why the microcontroller power is given from an external power source (5 V battery) backup and also the GSM module power is given from external power source(9V battery) because GSM module consumes lots of power. GSM module communicates with atmeg16 through UART. RXD of GSM module is connected with TXD of atmega16 and TXD of GSM module is connected to RXD of atmega16.

### b) *Receiving Side*

In receiver circuit another GSM Modem is connected with PC via USB-To-Serial converter. The GUI in MATLAB software has been is used such that it will read the message and the data will save it in an excel file and it will show a graph according to the data by using the interface. If any fault occurs, it is also capable to generate an alarm and a fault message box according to the fault. The communication protocol is UART and baud rate is 9600[4].

In view of the descriptions above, the implemented hardware can be found in figure 10.

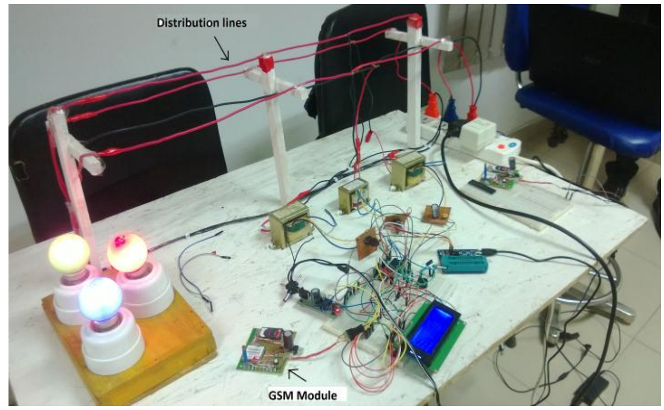



*Figure 10 :* Implemented Hardware model

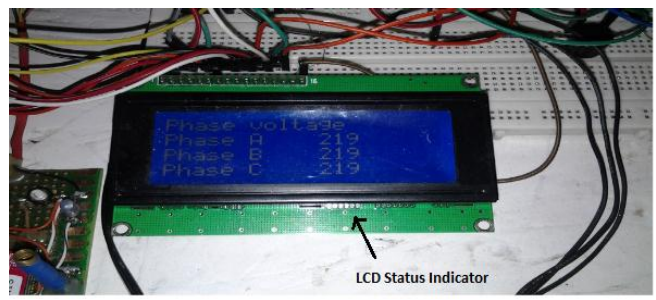



*Figure 11 :* LCD status indicator

As viewed from figure 10, the system was found to be balanced three phase system. In figure 11, the corresponding representation appears in the LCD display with the phase voltages in all the phases to be around 219 V. The view from GUI interface is also shown in figure 12.

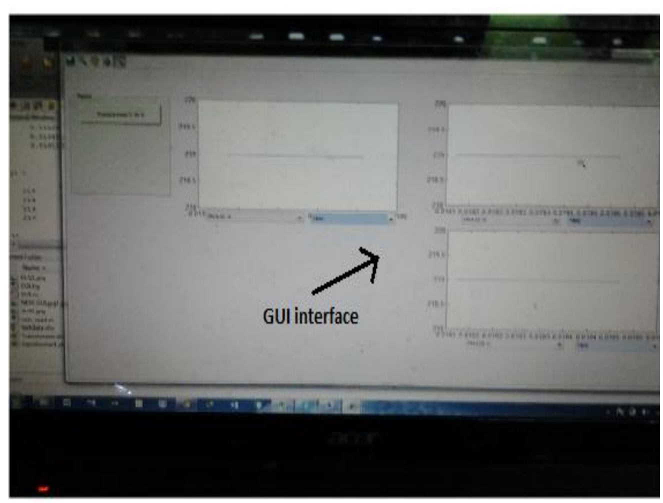



*Figure 12 :* GUI interface from PC

## VI. Future Prospects

In view of a wide range of possibilities on the basis of microcontroller based protection system, a few has been depicted below:

a) Fault detection of a wind turbine.
b) GPRS based network using internet for tracking transformer.
c) Improvements to human-machine interface
d) Improvements in computer-based protection of Industry automation
e) Long distance Data transmission.

## VII. Conclusion

Microcontroller and GSM based protection system is a reliable technique for monitoring and controlling the electric distribution system, the microcontroller works up to 100 ºC temperature. For long distance data transmission, GSM technology is a reliable and robust one. Any kind of fault occurring in the distribution system results the GSM modules to send instant messages automatically to the base station. Frequent fault occurrence can be a problem; in this case the cost of sending sms will increase resulting in account recharge in the GSM SIM number. This can be sloved in mutual agreement with telecom companies in Bangladesh (such as GP, Airtel, Banglalink, etc,). Nonetheless, GSM based microcontroller protection system will serve as a reliable, easy and cost effective solution for monitoring and controlling the electric distribution system.

## References Références Referencias

1. Grainger, John J. (2003). Power System Analysis. Tata McGraw-Hill. p. 380. ISBN 978-0-07-058515-7.
2. V. Thiyagarajan & T. G. Palanivel "AN EFFICIENT MONITORING OF SUBSTATIONSUSING MICRO-CONTROLLER BASED MONITORING SYSTEM" IJRRAS 4 (1). July 2010.
3. Datasheet of Atmega16" http://www.atmel.com/images/7766s.pdf"
4. Datasheet of sim900" http://garden.seeedstudio.-com/images/a/a8/SIM900_AT_Command_Manual_V1.03.pdf"
5. Wadhwa, C. L. (2005). "Electrical Power Systems". New Age International (P) Ltd., Publishers: New Delhi. Pp. 656-657.

This page is intentionally left blank

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 14 Issue 3 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

# Multiple Band Monopole Arm Microstrip Spiral Antenna for Cognitive Radio

By Dr. Vinitkumar Jayprakash Dongre & Miss Chitra Takle
*Thakur college of engineering & technology, India*

*Abstract-* The paper presents design of monopole arm microstrip spiral antenna that operates in the range of 2.93 to 7.25 GHz. The antenna is fed by an SMA connector from side, which is connected to a monopole i.e. main arm of spiral antenna. This monopole has a width of $\lambda_g/4$, which provide impedance matching thereby avoiding the need of balun for spiral antenna. To achieve enhancement in multiple band response, two designs have been proposed. The effect of increasing the number of turns of a spiral antenna is demonstrated here. The antenna is fabricated on FR-4 substrate with dielectric constant of 4.3 and loss tangent of $\delta$=0.025. The designed antenna when tested, is working in 8 frequency bands ranging from 2 to 8 GHz providing the total bandwidth of 1.4 GHz. This multiple band antenna is suitable for upcoming cognitive radio systems.

*Index Terms:* *cognitive radio, spiral antenna, multiple bands, microstrip transmission line.*

*GJRE-F Classification :* *FOR Code: 291701, 290901p*

MULTIPLEBANDMONOPOLEARMMICROSTRIPSPIRALANTENNAFORCOGNITIVERADIO

*Strictly as per the compliance and regulations of :*

# Multiple Band Monopole Arm Microstrip Spiral Antenna for Cognitive Radio

Dr. Vinitkumar Jayprakash Dongre [α] & Miss Chitra Takle [σ]

*Abstract-* The paper presents design of monopole arm microstrip spiral antenna that operates in the range of 2.93 to 7.25 GHz. The antenna is fed by an SMA connector from side, which is connected to a monopole i.e. main arm of spiral antenna. This monopole has a width of $\lambda_g/4$, which provide impedance matching thereby avoiding the need of balun for spiral antenna. To achieve enhancement in multiple band response, two designs have been proposed. The effect of increasing the number of turns of a spiral antenna is demonstrated here. The antenna is fabricated on FR-4 substrate with dielectric constant of 4.3 and loss tangent of $\delta$=0.025. The designed antenna when tested, is working in 8 frequency bands ranging from 2 to 8 GHz providing the total bandwidth of 1.4 GHz. This multiple band antenna is suitable for upcoming cognitive radio systems.

*Index Terms: cognitive radio, spiral antenna, multiple bands, microstrip transmission line.*

## I. Introduction

Currentwireless technologies require wide bands for personal wireless networks and selective bands for applications like WiMax (3.3-3.7 GHz), WLAN (5.15-5.825GHz), GSM (900-1800 MHz). Both wide band and selective band applications require different antennas. Today's wireless communication systems are expecting simple designs, higher data rates and low power consumption. The solution to these expectations was first proposed by Joseph Mitola III in 1998 which was cognitive radio. A cognitive radio is an intelligent radio that can be programmed and configured dynamically. It is transreceiver is designed to use the best wireless channel in its vicinity. Such a radio automatically detects available channels in wireless spectrum accordingly changes its transmission or reception parameters to allow more concurrent wireless communication in a given spectrum band at one location. Hence a multiple band response antenna is needed that can be used for cognitive radio. An antenna that operates over a wide frequency range with multiple bands separated by guard bands will be the most suitable one to support cognitive radio system. So that one single antenna can be used for above mentioned applications. Modern wireless communication systems that rely on multiple band antennas are becoming more popular for their ability to serve multiple standards using a single compact antenna, allowing a reduction in the dimensions of the wireless device and more space to integrate with other electronic components. Spiral antennas being the broad band antennas are the most suitable candidate for such applications.

Spiral antenna was first introduced by J.D. Dyson in 1959 which was based on Rumsey's principle [1] of frequency independent antennas [2]. Later, varieties of spiral antennas were introduced by many authors those were used for various applications [3-6].Different shapes of spiral antennas like Archimedean, rectangular, conical, logarithmic, slot spiral are being used for broad band applications to support high data rates [7-11]. Rectangular spiral antennas are the popular ones because of their geometry. Rectangular spiral antennas are easy to develop in simulation software, easy to fabricate. Many rectangular spiral antennas have been developed by authors that are useful for multiple purposes [12-14]. On the same lines a rectangular spiral antenna having multiple bands in different frequency bands that can be used for multiple applications is aimed to implement in this paper. Main aim is to get more number of resonances by increasing the number of turns.

## II. Design of Monopole Arm Rectangular Spiral Microstrip Antenna

The equation defining the well-known geometry of a round Archimedean spiral used in antenna designs is given as:

$$\rho = a\alpha + b \qquad (1)$$

Where ρ and a are the conventional polar coordinates in the x- z plane (ρ is the distance measured from the origin and a is the angle measured from the x axis), a is the growth rate and b is the starting point of spiral curve on the x axis. From the equation it is obvious that the Archimedean spiral arms have a constant amount of growth rate at each turn.

### *a) Basic Monopole Rectangular Spiral Antenna*

Square spiral approximates the round Archimedean spiral in this manner and therefore it always has the same distance between its arms [14]. The spiral arms are configured as rectangular monopole of λg/4 width to provide impedance matching with standard 50Ω and this eliminates the need of wideband balun design to feed the antenna. For the design of

*Author α σ: Thakur College of Engineering & Technology, Jaiganga, Near Charkop Police Station, Charkop Kandivali (West), Mumbai.*
*e-mail: taklechitra@gmail.com*

monopole the dimension width is more important and since the antenna is spiral so it's independent of the total length and only depends of spiral rotation. Width of the antenna has been calculated using microstrip transmission line equation [15]. The resonant frequency $f_r$ is chosen to be 9.2 GHz. The substrate used is FR4 so dielectric constant $\varepsilon_r$ is 4.3, with these values $\lambda_g$ comes to be 0.02. Therefore, ${}^{\lambda_g}/_{4} = 5$mm. $\lambda_g$ is guide wavelength. The width and length of ground plane is given by $W_g$ and $L_g$ in Eq. (4) and Eq. (9) [15]. The ground plane should be greater than or equal to both $W_g$ and $L_g$ . The lowest frequency is taken into consideration while calculating the dimensions of ground plane. So the lowest frequency is considered to be 1 GHz. Height of the substrate is taken to be 1.6 mm since we are using FR4 substrate. The width comes to be 92 mm, effective dielectric constant is 2.65 and Width (Wg) and length (Lg) of the ground plane is calculated 101.6 mm and 100.14 mm respectively. Hence the ground plane dimensions are taken to be 157 mm and 126 mm. Assuming the higher operating frequency of spiral as 9.2 GHz the width is calculated. Fig.1. shows the dimensions and geometry of microstrip spiral antenna.

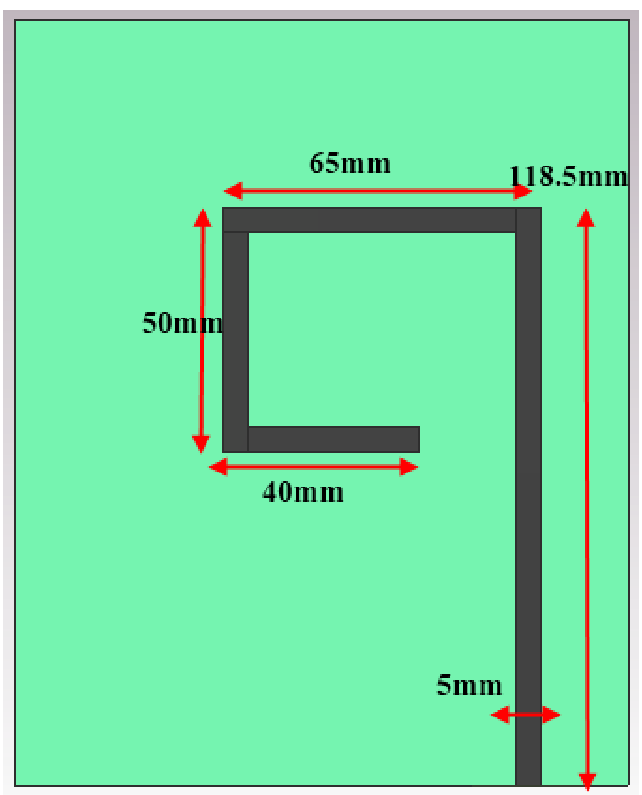



*Figure 1 :* Basic rectangular microstrip spiral antenna and its dimensions

*b) Increased turns in Basic Monopole Rectangular Spiral Antenna*

The current on spiral arm decays exponentially. More there's a scope for current to decay lesser are the multiple-resonances in frequency response. The bends of the spiral introduce sudden discontinuity in the current. When the next segment starts the current increases at the bend and again starts decaying till next bend. This increase and decrease of current gives multiple bands in the frequency response. So for more number of bands there should be more discontinuities i.e. more number of turns. The turns were too low in the previous design; when numbers of turns are increased the current distribution doesn't exponentially decreases incontinuous manner as its travel through the arms. As a result, multiple bands are obtained.

Fig. 2. shows the geometry of increased turn antenna. The length of second arm is approximately half of first arm. Second arm onwards, each arm length is decrease by 10 mm, till the arm vanishes. Here initially the current distribution should get a peak value, however the as the physical length increase (N increases), the current eventually start to decay exponentially.

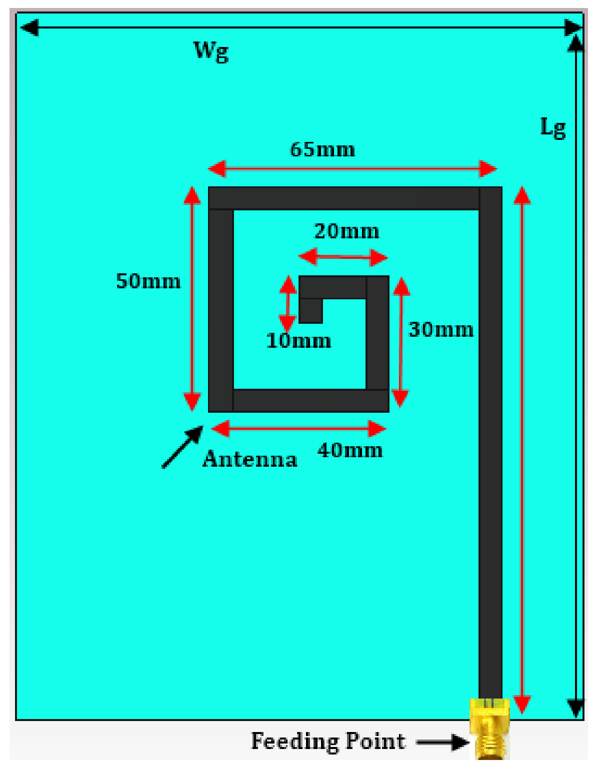



*Figure 2 :* Increased turns rectangular microstrip spiral antenna

## III. Results & Discussion

The simulations are done in Computer Simulation Tool Microwave studio (CST MWS) due to the fact that it provides a flexible GUI interface, various available numerical techniques like time domain, frequency domain, integral equation, asymptotic modes and Eigen mode. The simulation for proposed antenna are done using time domain solver of the CST MWS which saves the simulation time by using Finite Integral Numerical Technique. Since our main concern is to design a single antenna suitable for multiple applications that requires different frequencies, reflection coefficients are analysed and tested.

*a) Results of Basic Monopole Rectangular Spiral Antenna (Simulated)*

The plot of reflection coefficient (S11) for basic monopole rectangular spiral antenna is shown in the Fig.3. It is seen that the antenna is strongly resonating at four resonances at 3.74, 4.39, 4.78 and 5.8 GHz. The bands obtained below -10 dB are given in Table1. It is noted that the frequency response is weak above 5.5GHz due to the non-continuous decay of surface current along the spiral arms. Table 1 shows the frequency bands specifications for response shown in Fig.3. The total bandwidth obtained is 1.92 GHz. The numbers of resonances obtained are 7.

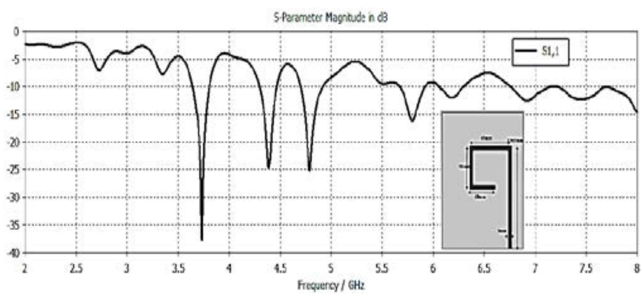



*Figure 3 :* Plot of reflection coefficient of Basic Monopole Rectangular Spiral Antenna (Simulated)

*Table I :* Band specification for Basic Monopole Rectangular Spiral Antenna.(Simulated)

| Sr. No. | Bands Obtained (GHz) | Resonances at (GHz) |
|---|---|---|
| 1 | 3.64 to 3.81 | 3.74 |
| 2 | 4.3 to 4.47 | 4.39 |
| 3 | 4.7 to 4.92 | 4.78 |
| 4 | 5.66 to 5.93 | 5.8 |
| 5 | 6.02 to 6.31 | 6.21 |
| 6 | 6.75 to 7.16 | 6.91 |
| 7 | 7.23 to 7.62 | 7.45 |

*b) Result of Increased Turns in Basic Monopole Rectangular Spiral Antenna (Simulated)*

The plot of reflection coefficient (S11) for increased turn design is shown in Fig.4. It depicts the changes in the frequency response due to increased turns. The antenna is resonating strongly at three resonances, 3.04, 3.73 and 4.34 GHz. Here, the number of selective bands that were observed below 5 GHz has been increased than previous design. This because, the current decays along each arm and experiences discontinuity at each bends. When the current distribution reaches a peak value we get resonance in the reflection coefficient. Increasing the number of turns increases the number of arms. At each arm, the current distribution reaches a peek value and again dies out at the end of the arm, which gives us more number of resonances in the reflection coefficient. Also increasing the number of turns causes the antenna size to increase which shifts the frequency response to lower frequency. In basic design the first resonance occurred at 3.74 GHz where in increased turn design the first resonance has occurred at 3.04 GHz. The analysis of bands obtained below -10 dB is shown in Table 2. The total bandwidth obtained is 2.28 GHz.

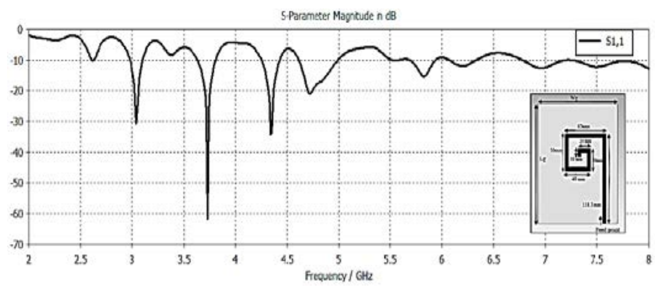



*Figure 4 :* Plot of reflection coefficient of increased turns Basic Monopole Rectangular Spiral Antenna (Simulated)

*Table II :* Band specification for increased turns in Basic Monopole Rectangular Spiral Antenna. (Simulated)

| Sr. No | Bands Obtained (GHz) | Resonances at (GHz) |
|---|---|---|
| 1 | 2.94 to 3.1 | 3.049 |
| 2 | 3.63 to 3.8 | 3.73 |
| 3 | 4.24 to 4.42 | 4.34 |
| 4 | 4.6 to 4.98 | 4.75 |
| 5 | 5.7 to 5.93 | 5.82 |
| 6 | 6.09 to 6.32 | 6.21 |
| 7 | 6.78 to 7.1 | 6.96 |
| 8 | 7.32 to 7.6 | 7.5 |
| 9 | 7.84 to 8 | 7.94 |

The increased turn antenna has been fabricated on FR4 substrate. The copper material on the substrate is coated with a thin layer of tin to prevent the oxidation of copper due to environmental affect. The fabricated antenna is shown in figure. A Standard 50 Ω SMA connector has been used to feed RF signal to the antenna. Fig.5. shows the photograph of fabricated antenna. The fabricated antenna is tested on a spectrum analyzer that can test the antenna up to 8 GHz. The results taken from the device are depicted in Fig.6.

*Figure 5 :* Photograph of fabricated increased turns rectangular microstrip spiral antenna

The analysis of bands obtained below -10 dB is shown in Table 3. Fig.7. shows the test setup for fabricated antenna. Table 4 shows the comparison of bands obtained by simulating and testing the antenna. It can be seen from Table 7 that the numbers of bands have been increased in fabricated antenna. If Table 1 and Table 2 are compared it is seen that the number resonant bands increase if the number of turns are increased. This is because of the number of bends occurring at each turn of the spiral.

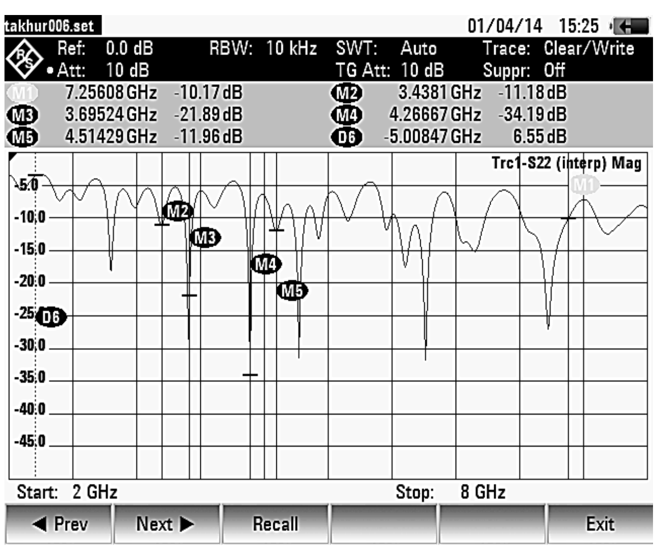



*Figure 6 :* Plot of reflection coefficient of increased turns Basic Monopole Rectangular Spiral Antenna (Tested on Rohde & Schwarz spectrum analyser)

*Table III :* Band specification for increased turns in Basic Monopole Rectangular Spiral Antenna (Tested)

| Sr. No | Bands Obtained (GHz) | Resonances at (GHz) |
|---|---|---|
| 1 | 2.93 to 2.98 | 2.96 |
| 2 | 3.4 to 3.46 | 3.43 |
| 3 | 3.64 to 3.72 | 3.69 |
| 4 | 4.22 to 4.31 | 4.26 |
| 5 | 4.49 to 4.53 | 4.51 |
| 6 | 4.67 to 4.77 | 4.72 |
| 7 | 5.54 to 5.58 | 5.55 |
| 8 | 5.64 to 5.97 | 5.72 |
| 9 | 6.19 to 6.47 | 6.39 |
| 10 | 6.82 to 7.25 | 7.08 |

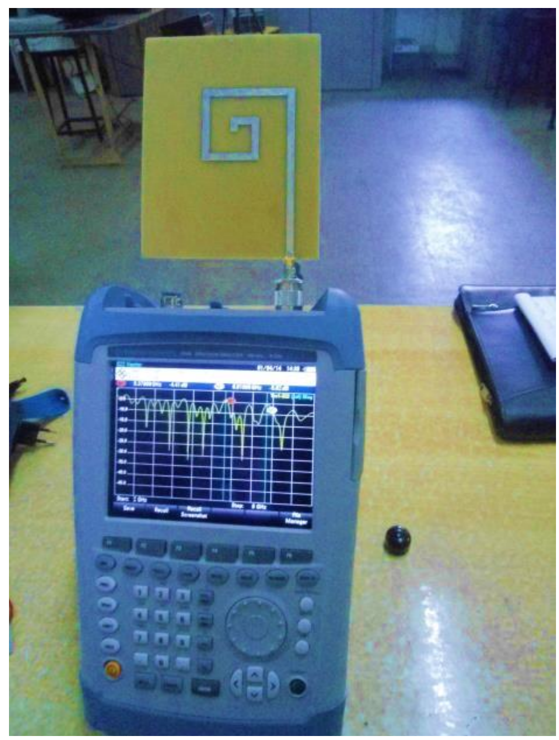


*Figure 7 :* Test setup for fabricated antenna

It is observed from the Table 7 that the resonances of simulated and tested results are not the same. This must have occurred due to the fabrication inaccuracies. However, our main goal of increasing the number of resonances has been fulfilled. This single antenna can support various applications in different band since it has multiple resonances.

*Table IV :* Comaprison of Band specifications for increased turns in Basic Monopole Rectangular Spiral Antenna

| Bands Obtained (Simulated) (GHz) | | Bands Obtained (Tested) (GHz) |
|---|---|---|
| 2.9 to 3.1 | | 2.93 to 2.98 |
| 3.63 to 3.8 | | 3.4 to 3.46 |
| 4.24 to 4.42 | | 3.64 to 3.72 |
| 4.6 to 4.98 | | 4.22 to 4.31 |
| 5.7 to 5.93 | | 4.49 to 4.53 |
| 6.09 to 6.32 | | 4.67 to 4.77 |
| 6.78 to 7.1 | | 5.54 to 5.58 |
| 7.32 to 7.6 | | 5.64 to 5.97 |
| 7.84 to 8 | | 6.19 to 6.47 |
| - | | 6.82 to 7.25 |
| Number of bands | 9 | 10 |

## IV. Conclusion

The proposed antenna works in IEEE C band and IEEE S band as well with multiple resonances. The resonances obtained in result includes worldwide interoperability for microwave access i.e. WiMax (3.3 - 3.7 GHz), IEEE 802.11a in the United States (5.15 – 5.35 GHz, 5.725-5.825 GHz) and HIPERLAN/2 in Europe (5.15 – 5.35 GHz, 5.47 – 5.725 GHz). Since the antenna has multiple band response, the proposed antenna is also suitable to be used in future cognitive radio systems. This antenna can also be used for beam switching in a particular direction to increase the gain towards an access point. Beam switching can be implemented with use of switching action provided by the use of microwave switches to change the physical and electrical length of the antenna.

## References Références Referencias


1. H. Rumsey, "Frequency independent antennas," *IRE National Convention Record*, pt. 1, pp. 114-118, 1957.
2. John D. Dyson, "The unidirectional equiangular spiral antenna," *IRE Transaction on Antenna and Propagation,* vol. AP-7, no. 4, pp. 329–334, October 1959.
3. R. Bawer and J. J. Wolfe, "The spiral antenna," *IRE Int. Convention Record*, pp. 84–95, New York, March 1960.
4. J. A. Kaiser, "The Archimedean two-wire spiral antenna," *IRE Transaction Antennas Propagation*, vol. AP-8, no. 3, pp. 312–323, May 1960.
5. H. Nakano, K. Nogami, S. Arai, H. Mimaki, and J. Yamauchi, "A spiral antenna backed by a conducting plane reflector," *IEEE Transaction Antennas Propagation*, vol. 34, pp. 791–796, June 1986.
6. C. A. Balanis, Antenna Theory: Analysis and Design. New York: Wiley, 1997.
7. Michael McFadden, Waymond R. Scott Jr., "Analysis of the equiangular spiral antenna on a dielectric substrate," *IEEE Transactions On Antennas And Propagation*, vol. 55, no. 11, pp. 3163-3171, November 2007.
8. Dominikus J. Müller, Kamal Sarabandi, "Design and analysis of a 3-arm spiral antenna," *IEEE Transactions on Antennas and Propagation*, vol. 55, No. 2, pp. 258-266, February 2007.
9. P. Piksa, M. Mazánek, "A self-complementary 1.2 to 40 GHz spiral antenna with impedance matching," *Radioengineering*, vol. 15, no. 3, pp. 15-19, September 2006.
10. Thorsten W. Hertel, Glenn S. Smith, "Analysis and design of two-arm conical spiral antennas," *IEEE Transactions On Electromagnetic Compatibility*, vol. 44, no. 1, pp. 25-37, February 2002.
11. Thaysen, J., K. B. Jakobsen, and Appel-Hansen, "A logarithmic spiral antenna for 0.4 to 3.8 GHz," *Applied Microwaves and Wireless*, pp.32-45, 2002.
12. Cheng-Nan Chiu, Wen-Hao Chuang, "A Novel Dual-Band Spiral Antenna for a Satellite and Terrestrial Communication System", IEEE Antennas and Wireless Propagation Letters, vol. 8, pp. 624 – 626, 2009.
13. K. Q. da Costa, V. Dmitriev, C. Rodrigues, "Fractal Spiral Monopoles: theoretical analysis and bandwidth optimization", SBMO/IEEE, MTT-S, IMOC, Brasília-DF, Brasil, July 2005.
14. K. Q. da Costa, V. Dmitriev, C. Rodrigues, "Fractal Spiral Monopoles: theoretical analysis and bandwidth optimization", SBMO/IEEE, MTT-S, IMOC, Brasília-DF, Brasil, July 2005.
15. K. Praveen Kumar, K. Sanjeeva Rao, "Effect of feeding techniques on the radiation characteristics of patch antenna: design and analysis", *International Journal of Advanced Research in Computer and Communication Engineering,* Vol. 2, Issue 2, February 2013.


Global Journal of Researches in Engineering ( F ) Volume XIV Issue III Version I Year 2014

This page is intentionally left blank

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 14 Issue 3 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

# Voltage Profile Augmentation and Minimization of Real Power Loss in Transmission Lines by using Improved Hybrid Particle Swarm Optimization-Based on Harmony Search Algorithm

By K. Lenin, Dr. B. Ravindranath Reddy & Dr. M. Surya Kalavathi

*American International University, India*

*Abstract-* In this paper, a new particle swarm search algorithm is proposed to solve the optimal reactive power dispatch (ORPD) Problem. The ORPD problem is formulated as a nonlinear constrained single-objective optimization problem where the real power loss and the bus voltage deviations are to be minimized separately. As an optimization technique, particle swarm optimization (PSO) has obtained much attention during the past decade. It is gaining popularity, especially because of the speed of convergence and the fact that it is easy to realize. To enhance the performance of PSO, an improved hybrid particle swarm optimization (IHPSO) is proposed to solve complex optimization problems more efficiently, accurately and reliably. It provides a new way of producing new individuals through organically merges the harmony search (HS) method into particle swarm optimization (PSO). During the course of evolvement, harmony search is used to generate new solutions and this makes IHPSO algorithm have more powerful exploitation capabilities. In order to evaluate the performance of the proposed algorithm, it has been tested on IEEE 30 bus system.

*Keywords: modal analysis, optimal reactive power, transmission loss, particle swarm, harmony search metaheuristic.*

*GJRE-F Classification : FOR Code: 090607*

# Voltage Profile Augmentation and Minimization of Real Power Loss in Transmission Lines by using Improved Hybrid Particle Swarm Optimization-Based on Harmony Search Algorithm

K. Lenin α, Dr. B. Ravindranath Reddy σ & Dr. M. Surya Kalavathi ρ



*Abstract-* In this paper, a new particle swarm search algorithm is proposed to solve the optimal reactive power dispatch (ORPD) Problem. The ORPD problem is formulated as a nonlinear constrained single-objective optimization problem where the real power loss and the bus voltage deviations are to be minimized separately. As an optimization technique, particle swarm optimization (PSO) has obtained much attention during the past decade. It is gaining popularity, especially because of the speed of convergence and the fact that it is easy to realize. To enhance the performance of PSO, an improved hybrid particle swarm optimization (IHPSO) is proposed to solve complex optimization problems more efficiently, accurately and reliably. It provides a new way of producing new individuals through organically merges the harmony search (HS) method into particle swarm optimization (PSO). During the course of evolvement, harmony search is used to generate new solutions and this makes IHPSO algorithm have more powerful exploitation capabilities. In order to evaluate the performance of the proposed algorithm, it has been tested on IEEE 30 bus system.

*Keywords: modal analysis, optimal reactive power, transmission loss, particle swarm, harmony search metaheuristic.*

## I. Introduction

In recent years the optimal reactive power dispatch (ORPD) problem has received great attention as a result of the improvement on economy and security of power system operation. Solutions of ORPD problem aim to minimize object functions such as fuel cost, power system loses, etc. while satisfying a number of constraints like limits of bus voltages, tap settings of transformers, reactive and active power of power resources and transmission lines and a number of controllable Variables [ 1, 2]. In the literature, many methods for solving the ORPD problem have been done up to now. At the beginning, several classical methods such as gradient based [3], interior point [4], linear programming [5] and quadratic programming [6] have been successfully used in order to solve the ORPD problem. However, these methods have some disadvantages in the Process of solving the complex ORPD problem. Drawbacks of these algorithms can be declared insecure convergence properties, long execution time, and algorithmic complexity. Besides, the solution can be trapped in local minima [1, 7]. In order to overcome these disadvantages, researches have successfully applied evolutionary and heuristic algorithms such as Genetic Algorithm (GA) [2], Differential Evolution (DE) [8], Particle Swarm Optimization (PSO) [9] and harmony search algorithms [10-11].This paper formulates the reactive power dispatch as a multi-objective optimization problem with loss minimization and maximization of static voltage stability margin (SVSM) as the objectives. Voltage stability evaluation using modal analysis [12] is used as the indicator of voltage stability. Function optimization has received extensive research attention, and several optimization algorithm such as neural networks [13], evolutionary algorithms [14], genetic algorithms [15] and swarm intelligence-based algorithms [16-17] have been developed and applied successfully to solve a wide range of complex optimization problems. Most stochastic optimization algorithms including particle swarm optimizer (PSO) [18, 19] and genetic algorithm (GA) [15] have shown inadequate to complex optimization problems, as they rapidly push an artificial population toward convergence. That is, all individuals in the population soon become nearly identical. To improve PSO performance, several methods have been proposed. Many of these methods concerned predefining numerical coefficients, consisting of the maximum velocity, inertia weight, social factor and individual factor, which can affect various characteristics of the algorithm, such as convergence rate or the ability of global optimization. Recently, some hybrid implementations of PSO algorithm with other search

*Author α: Research Scholar, Jawaharlal Nehru Technological University Kukatpally, Hyderabad, India. e-mail: gklenin@gmail.com*
*Author σ: Deputy Executive Engineer, Jawaharlal Nehru Technological University Kukatpally, Hyderabad, India.*
*Author ρ: Professor of Electrical and Electronics Engineering, Jawaharlal Nehru Technological University Kukatpally, Hyderabad, India.*

methods. NM-PSO (Nelder- Mead-PSO) [20] comprises NM method at the top of level, and PSO at the lower level. CPSO (Chaotic PSO) [21] applies PSO to perform global exploration and chaotic local search to perform local search on the solutions produced in the global exploration process. These methods can equip PSO with extra facilities. In this paper, an improved PSO (IPSO) based of harmony search (HS) [22, 23] is proposed to solve complex optimizations. The PSO algorithm includes some tuning parameters that greatly influence the algorithm performance, often stated as the exploration-exploitation trade off: Exploration is the ability to test various regions in the problem space in order to locate a good optimum, hopefully the global one. Exploitation is the ability to concentrate the search around a promising candidate solution in order to locate the optimum precisely. Facing complicated optimizations, it's difficult to explore every possible region of the search space. Recently, harmony search (HS) algorithm imitates the improvisation process of music players and had been very successful in a wide variety of optimization problems [24-25], presenting several advantages with respect to traditional optimization techniques such as the following [24]:(a) HS algorithm imposes fewer mathematical requirements and does not require initial value settings of the decision variables. (b) As the HS algorithm uses stochastic random searches, derivative information is also unnecessary. (c) The HS algorithm generates a new vector, after considering all of the existing vectors, whereas the genetic algorithm (GA) only considers the two parent vectors. These features increase the flexibility of the HS algorithm and produce better solutions. In this study, one of the ways of integrating the concepts of these two optimization algorithms for solving complex optimization problems is explored. The performance of IHPSO has been evaluated in standard IEEE 30 bus test system and the results analysis shows that our proposed approach outperforms all approaches investigated in this paper.

## II. Voltage Stability Evaluatio

*a) Modal analysis for voltage stability evaluation*

The linearized steady state system power flow equations are given by.

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_{p\theta} & J_{pv} \\ J_{q\theta} & J_{QV} \end{bmatrix} \quad (1)$$

Where

$\Delta P$ = Incremental change in bus real power.

$\Delta Q$ = Incremental change in bus reactive Power injection

$\Delta\theta$ = incremental change in bus voltage angle.

$\Delta V$ = Incremental change in bus voltage Magnitude

$J_{p\theta}$ , $J_{PV}$ , $J_{Q\theta}$ , $J_{QV}$ jacobian matrix are the sub-matrixes of the System voltage stability is affected by both P and $Q$. However at each operating point we keep P constant and evaluate voltage stability by considering incremental relationship between $Q$ and V.

To reduce (1), let $\Delta P = 0$ , then.

$$\Delta Q = \left[J_{QV} - J_{Q\theta} J_{P\theta^{-1}} J_{PV}\right] \Delta V = J_R \Delta V \quad (2)$$

$$\Delta V = J^{-1} - \Delta Q \quad (3)$$

Where

$$J_R = \left(J_{QV} - J_{Q\theta} J_{P\theta^{-1}} JPV\right) \quad (4)$$

$J_R$ is called the reduced Jacobian matrix of the system.

*a) Modes of Voltage instability*

Voltage Stability characteristics of the system can be identified by computing the eigen values and eigen vectors

Let

$$J_R = \xi \wedge \eta \quad (5)$$

Where,

$\xi$ = right eigenvector matrix of $J_R$

$\eta$ = left eigenvector matrix of $J_R$

$\wedge$ = diagonal eigenvalue matrix of $J_R$ and

$$J_{R^{-1}} = \xi \wedge^{-1} \eta \quad (6)$$

From (3) and (6), we have

$$\Delta V = \xi \wedge^{-1} \eta \Delta Q \quad (7)$$

or

$$\Delta V = \sum_I \frac{\xi_i \eta_i}{\lambda_i} \Delta Q \quad (8)$$

Where $\xi_i$ is the ith column right eigenvector and $\eta$ the ith row left eigenvector of $J_R$.

$\lambda_i$ is the ith eigen value of $J_R$.

The ith modal reactive power variation is,

$$\Delta Q_{mi} = K_i \xi_i \quad (9)$$

where,

$$K_i = \sum_j \xi_{ij^2} - 1 \quad (10)$$

Where

$\xi_{ji}$ is the jth element of $\xi_i$

The corresponding ith modal voltage variation is

$$\Delta V_{mi} = [1/\lambda_i] \Delta Q_{mi} \quad (11)$$

In (8), let $\Delta Q = e_k$ where $e_k$ has all its elements zero except the kth one being 1. Then,

$$\Delta V = \sum_i \frac{\eta_{1k}\ \xi_1}{\lambda_1} \tag{12}$$

$\eta_{1k}$ k th element of $\eta_1$

V –Q sensitivity at bus k

$$\frac{\partial V_K}{\partial Q_K} = \sum_i \frac{\eta_{1k}\ \xi_1}{\lambda_1} = \sum_i \frac{P_{ki}}{\lambda_1} \tag{13}$$

## III. Problem Formulation

The objectives of the reactive power dispatch problem considered here is to minimize the system real power loss and maximize the static voltage stability margins (SVSM).

### a) Minimization of Real Power Loss

Minimization of the real power loss (Ploss) in transmission lines of a power system is mathematically stated as follows.

$$P_{loss} = \sum_{\substack{k=1 \\ k=(i,j)}}^{n} g_{k(V_i^2+V_j^2-2V_i V_j \cos\theta_{ij})} \tag{14}$$

Where n is the number of transmission lines, $g_k$ is the conductance of branch k, $V_i$ and $V_j$ are voltage magnitude at bus i and bus j, and θij is the voltage angle difference between bus i and bus j.

### b) Minimization of Voltage Deviation

Minimization of the Deviations in voltage magnitudes (VD) at load buses is mathematically stated as follows.

$$\text{Minimize VD} = \sum_{k=1}^{nl} |V_k - 1.0| \tag{15}$$

Where nl is the number of load busses and $V_k$ is the voltage magnitude at bus k.

### c) System Constraints

In the minimization process of objective functions, some problem constraints which one is equality and others are inequality had to be met. Objective functions are subjected to these constraints shown below.

Load flow equality constraints:

$$P_{Gi} - P_{Di} - V_{i\sum_{j=1}^{nb} V_j} \begin{bmatrix} G_{ij} & \cos\theta_{ij} \\ +B_{ij} & \sin\theta_{ij} \end{bmatrix} = 0, i = 1,2 \ldots., nb \tag{16}$$

$$Q_{Gi} - Q_{Di} V_{i\sum_{j=1}^{nb} V_j} \begin{bmatrix} G_{ij} & \cos\theta_{ij} \\ +B_{ij} & \sin\theta_{ij} \end{bmatrix} = 0, i = 1,2 \ldots., nb \tag{17}$$

where, *nb* is the number of buses, $P_G$ and $Q_G$ are the real and reactive power of the generator, $P_D$ and $Q_D$ are the real and reactive load of the generator, and $G_{ij}$ and $B_{ij}$ are the mutual conductance and susceptance between bus *i* and bus *j*.

Generator bus voltage ($V_{Gi}$) inequality constraint

$$V_{Gi}^{min} \le V_{Gi} \le V_{Gi}^{max}, i \in ng \tag{18}$$

Load bus voltage ($V_{Li}$) inequality constraint

$$V_{Li}^{min} \le V_{Li} \le V_{Li}^{max}, i \in nl \tag{19}$$

Switchable reactive power compensations ($Q_{Ci}$) inequality constraint:

$$Q_{Ci}^{min} \le Q_{Ci} \le Q_{Ci}^{max}, i \in nc \tag{20}$$

Reactive power generation ($Q_{Gi}$) inequality constraint:

$$Q_{Gi}^{min} \le Q_{Gi} \le Q_{Gi}^{max}, i \in ng \tag{21}$$

Transformers tap setting ($T_i$) inequality constraint:

$$T_i^{min} \le T_i \le T_i^{max}, i \in nt \tag{22}$$

Transmission line flow ($S_{Li}$) inequality constraint:

$$S_{Li}^{min} \le S_{Li}^{max}, i \in nl \tag{23}$$

Where, nc, ng and nt are numbers of the switchable reactive power sources, generators and transformers.

## IV. Standard PSO

PSO is a population-based, co-operative search meta-heuristic introduced by Kennedy and Eberhart. The fundament for the development of PSO is hypothesis that a potential solution to an optimization problem is treated as a bird without quality and volume, which is called a particle, coexisting and evolving simultaneously based on knowledge sharing with neighbouring particles. While flying through the problem search space, each particle modifies its velocity to find a better solution (position) by applying its own flying experience (i.e. memory having best position found in the earlier flights) and experience of neighbouring particles (i.e. best-found solution of the population). Particles update their positions and velocities as shown below:

$$v_{t+1}^i = \omega_t . v_t^i + c_1 . R_1 . (p_t^i - x_t^i) + c_2 . R_2 . (p_t^g - x_t^i) \tag{24}$$

$$x_{t+1}^i = x_t^i + v_{t+1}^i \tag{25}$$

Where $x_t^i$ represents the current position of particle i in solution space and subscript t indicates an iteration count; $p_t^i$ is the best-found position of particle i up to iteration count t and represents the cognitive contribution to the search velocity $v_t^i$ . Each component of $v_t^i$ can be clamped to the range to control excessive roaming of particles outside the search space; $p_t^g$ is the global best-found position among all particles in the swarm up to iteration count t and forms the social contribution to the velocity vector; $r_1$ and $r_2$ are random numbers uniformly distributed in the interval (0,1), where $c_1$ and $c_2$ are the cognitive and social scaling parameters, respectively; $\omega_t$ is the particle inertia, which is reduced dynamically to decrease the search area in a gradual fashion [25]. The variable $\omega_t$ is updated as

$$\omega_t = (\omega_{max} - \omega_{min}).\frac{(t_{max} - t)}{t_{max}} + \omega_{min} \qquad (26)$$

Where$\omega_{max}$ and $\omega_{min}$ denote the maximum and minimum of $\omega_t$ respectively; $t_{max}$ is a given number of maximum iterations. Particle i fly toward a new position according to Eq. (24) and (25). In this way, all particles of the swarm find their new positions and apply these new positions to update their individual best $p_t^i$ points and global best $p_t^g$ of the swarm. This process is repeated until termination conditions are met.

## V. Harmony Search

Harmony search (HS) algorithm is based on natural musical performance processes that occur when a musician searches for a better state of harmony, such as during jazz improvisation. The engineers seek for a global solution as determined by an objective function, just like the musicians seek to find musically pleasing harmony as determined by an aesthetic [26]-[27]. In music improvisation, each player sounds any pitch within the possible range, together making one harmony vector. If all the pitches make a good solution, that experience is stored in each variable's memory, and the possibility to make a good solution is also increased next time. HS algorithm includes a number of optimization operators, such as the harmony memory (HM), the harmony memory size (HMS, number of solution vectors in harmony memory), the harmony memory considering rate (HMCR), and the pitch adjusting rate (PAR). In the HS algorithm, the harmony memory (HM) stores the feasible vectors, which are all in the feasible space. The harmony memory size determines how many vectors it stores. A new vector is generated by selecting the components of different vectors randomly in the harmony memory. For example, Consider a jazz trio composed of saxophone, double bass and guitar. There exist certain amount of preferable pitches in each musician's memory: saxophonist, {Do, Mi, Sol}; double bassist, {Si, Sol, Re}; and guitarist, {La, Fa, Do}. If saxophonist randomly plays {Sol} out of {Do, Mi, Sol}, double bassist {Si} out of {Si, Sol, Re}, and guitarist {Do} out of {La, Fa, Do}, that harmony (Sol, Si, Do) makes another harmony (musically C-7 chord). And if the New Harmony is better than existing worst harmony in the HM, the New Harmony is included in the HM and the worst harmony is excluded from the HM. This procedure is repeated until fantastic harmony is found. When a musician improvises one pitch, usually he (or she) follows any one of three rules: (a) playing any one pitch from his (or her) memory, (b) playing an adjacent pitch of one pitch from his (or her) memory, and (c) playing totally random pitch from the possible sound range. Similarly, when each decision variable chooses one value in the HS algorithm, it follows any one of three rules: (i) choosing any one value from HS memory (defined as memory considerations), (ii) choosing an adjacent value of one value from the HS memory (defined as pitch adjustments), and (iii) choosing totally random value from the possible value range (defined as randomization). The three rules in HS algorithm are effectively directed using two parameters, i.e., harmony memory considering rate (HMCR) and pitch adjusting rate (PAR).

The steps in the procedure of harmony search are as follows:

*Step 1:* Initialize the problem and algorithm parameters.

*Step 2:* Initialize the harmony memory (HM).

*Step 3:* Improvise a new harmony from the HM.

*Step 4:* Update the HM.

*Step 5:* Repeat Steps 3 and 4 until the termination criterion is satisfied.

## VI. The Realization of ihpso based of hs

This section describes the implementation of proposed improvement in PSO using HS approach. The proposed method, called, IHPSO (improved hybrid particle swarm optimization) is based on the common characteristics of both PSO and HS algorithms. HS algorithm provides a new way to produce new particles. Different from PSO and GA, HS algorithm generates a new vector after considering all of the existing vectors. HS algorithm can produce new solution and the parameters of HMCR and PAR are introduced to allow the solution to escape from local optima and to improve the global optimum prediction of the algorithm. Enlightened by this, the HS realization concept has been used in the PSO in this paper to exploration the potential solution space. In summary，the realization of improved PSO algorithm for solving reactive power dispatch is described as follows:

*Step 1:* Initializing the parameters of PSO and HS;

*Step 2:* Initailizing the particles;

*Step 3:* Evaluating particles according to their fitness then descending sort them;

*Step 4:* Performing HS and generating a new solution;

*Step 5:* If the new solution is better than the worst particle then replacing it with the new one;

*Step 6:* Update the particles by using equation's (24) & (25)

*Step 7:* The program is finished if the terminations conditions are met otherwise go to step3.

Improvising a new harmony from the HM can be realized as follows:

A New Harmony vector $x' = \{x_1', x_2', \wedge, x_N'\}$ is generated from the HM based on memory considerations, pitch adjustments, and randomization. For instance, the value of for the new vector can be chosen from any value in the specified HM rang $(x_1^1 - x_1^{HMS})$. Values of the other design variables can be chosen in the same manner. Here, it's possible to choose the new value using the HMCR parameter, which varies between 0 and 1 as follows:

$$x_i' \leftarrow \begin{cases} x_i' \in \{x_i^1, x_i^2, \wedge, x_i^{HMS}\}\ with\ probability\ HMCR \\ x_i' \in X_i\ with\ probability\ 1 - HMCR \end{cases} \quad (27)$$

The HMCR is the probability of choosing one value from the historic values stored in the HM, and (1-HMCR) is the probability of randomly choosing one feasible value not limited to those stored in the HM. For example, an HMCR of 0.95 indicates that the HS algorithm will choose the design variable value from historically stored values in the HM with a 95% probability and from the entire feasible range with a 5% probability. An HMCR value of 1.0 is not recommended because of the possibility that the solution may be improved by values not stored in the HM. This is similar to the reason why the genetic algorithm uses a mutation rate in the selection process. Every component of the New Harmony vector $x' = \{x_1', x_2', \wedge, x_N'\}$ is examined to determine whether it should be pitch-adjusted. This procedure uses the parameter that set the rate of adjustment for the pitch chosen from the HM as follows: Pitch adjusting decision for

$$x_i' \leftarrow \begin{cases} Yes\ with\ probability\ PAR \\ No\ with\ probability\ 1 - PAR \end{cases} \quad (28)$$

The Pitch adjusting process is performed only after a value is chosen from the HM. The value (1-PAR) sets the rate of doing nothing. A PAR of 0.3 indicates that the algorithm will choose a neighbouring value with probability. If the pitch adjustment decision for $x'$ is Yes, and $x'$ is assumed to be $x_i(k)$ i.e., the kth element in $X_i$, the pitch-adjusted value of $x_i(k)$ is:

$$x' = x' + \alpha \quad (29)$$

Where $\alpha -$ the value of is $bw \times (1, -1)$, $bw$ is an arbitrary distance bandwidth for the continuous design variable, and u (−1, 1) is a uniform distribution between -1 and 1. The HMCR and PAR parameters introduced in the harmony search help the algorithm escape from local optima and to improve the global optimum prediction of the HS algorithm. After improvising a new harmony, evaluating the new one and if it is better than the worst one in the HM in terms of the objective function value, the new one is included in the HM and the existing worst harmony is excluded from the HM. The HM is then sorted by the objective function value.

## VII. Simulation Results

The accuracy of the proposed IHPSO Algorithm method is demonstrated by testing it on standard IEEE-30 bus system. The IEEE-30 bus system has 6 generator buses, 24 load buses and 41 transmission lines of which four branches are (6-9), (6-10) , (4-12) and (28-27) - are with the tap setting transformers. The lower voltage magnitude limits at all buses are 0.95 p.u. and the upper limits are 1.1 for all the PV buses and 1.05 p.u. for all the PQ buses and the reference bus. The simulation results have been presented in Tables 1, 2, 3 &4. And in the Table 5 shows the proposed algorithm powerfully reduces the real power losses when compared to other given algorithms. The optimal values of the control variables along with the minimum loss obtained are given in Table 1. Corresponding to this control variable setting, it was found that there are no limit violations in any of the state variables.

*Table 1 :* Results of IHPSO – ORPD Optimal Control Variables

| Control variables | Variable setting |
|---|---|
| V1 | 1.040 |
| V2 | 1.041 |
| V5 | 1.040 |
| V8 | 1.030 |
| V11 | 1.003 |
| V13 | 1.041 |
| T11 | 1.01 |
| T12 | 1.00 |
| T15 | 1.0 |
| T36 | 1.0 |
| Qc10 | 3 |
| Qc12 | 4 |
| Qc15 | 4 |
| Qc17 | 0 |
| Qc20 | 3 |
| Qc23 | 4 |
| Qc24 | 3 |
| Qc29 | 3 |
| Real power loss | 4.2985 |
| SVSM | 0.2482 |

ORPD together with voltage stability constraint problem was handled in this case as a multi-objective optimization problem where both power loss and maximum voltage stability margin of the system were optimized simultaneously. Table 2 indicates the optimal values of these control variables. Also it is found that there are no limit violations of the state variables. It indicates the voltage stability index has increased from 0.2482 to 0.2498, an advance in the system voltage stability. To determine the voltage security of the system, contingency analysis was conducted using the control variable setting obtained in case 1 and case 2. The Eigen values equivalents to the four critical contingencies are given in Table 3. From this result it is observed that the Eigen value has been improved considerably for all contingencies in the second case.

*Table 2 :* Results of Ihpso -Voltage Stability Control Reactive Power Dispatch Optimal Control Variables

| Control Variables | Variable Setting |
|---|---|
| V1 | 1.043 |
| V2 | 1.044 |
| V5 | 1.042 |
| V8 | 1.031 |
| V11 | 1.005 |
| V13 | 1.035 |
| T11 | 0.090 |
| T12 | 0.090 |
| T15 | 0.090 |
| T36 | 0.090 |
| Qc10 | 4 |
| Qc12 | 4 |
| Qc15 | 3 |
| Qc17 | 4 |
| Qc20 | 0 |
| Qc23 | 3 |
| Qc24 | 3 |
| Qc29 | 4 |
| Real power loss | 4.9690 |
| SVSM | 0.2498 |

*Table 3 :* Voltage Stability Under Contingency State

| Sl.No | Contigency | ORPD Setting | VSCRPD Setting |
|---|---|---|---|
| 1 | 28-27 | 0.1410 | 0.1425 |
| 2 | 4-12 | 0.1658 | 0.1665 |
| 3 | 1-3 | 0.1774 | 0.1783 |
| 4 | 2-4 | 0.2032 | 0.2045 |

*Table 4 :* Limit Violation Checking of State Variables

| State variables | limits | | ORPD | VSCRPD |
|---|---|---|---|---|
| | Lower | upper | | |
| Q1 | -20 | 152 | 1.3422 | -1.3269 |
| Q2 | -20 | 61 | 8.9900 | 9.8232 |
| Q5 | -15 | 49.92 | 25.920 | 26.001 |
| Q8 | -10 | 63.52 | 38.8200 | 40.802 |
| Q11 | -15 | 42 | 2.9300 | 5.002 |
| Q13 | -15 | 48 | 8.1025 | 6.033 |
| V3 | 0.95 | 1.05 | 1.0372 | 1.0392 |
| V4 | 0.95 | 1.05 | 1.0307 | 1.0328 |
| V6 | 0.95 | 1.05 | 1.0282 | 1.0298 |
| V7 | 0.95 | 1.05 | 1.0101 | 1.0152 |
| V9 | 0.95 | 1.05 | 1.0462 | 1.0412 |
| V10 | 0.95 | 1.05 | 1.0482 | 1.0498 |
| V12 | 0.95 | 1.05 | 1.0400 | 1.0466 |
| V14 | 0.95 | 1.05 | 1.0474 | 1.0443 |
| V15 | 0.95 | 1.05 | 1.0457 | 1.0413 |
| V16 | 0.95 | 1.05 | 1.0426 | 1.0405 |
| V17 | 0.95 | 1.05 | 1.0382 | 1.0396 |
| V18 | 0.95 | 1.05 | 1.0392 | 1.0400 |
| V19 | 0.95 | 1.05 | 1.0381 | 1.0394 |
| V20 | 0.95 | 1.05 | 1.0112 | 1.0194 |
| V21 | 0.95 | 1.05 | 1.0435 | 1.0243 |
| V22 | 0.95 | 1.05 | 1.0448 | 1.0396 |
| V23 | 0.95 | 1.05 | 1.0472 | 1.0372 |
| V24 | 0.95 | 1.05 | 1.0484 | 1.0372 |
| V25 | 0.95 | 1.05 | 1.0142 | 1.0192 |
| V26 | 0.95 | 1.05 | 1.0494 | 1.0422 |
| V27 | 0.95 | 1.05 | 1.0472 | 1.0452 |
| V28 | 0.95 | 1.05 | 1.0243 | 1.0283 |
| V29 | 0.95 | 1.05 | 1.0439 | 1.0419 |
| V30 | 0.95 | 1.05 | 1.0418 | 1.0397 |

*Table 5 :* Comparison of Real Power Loss

| Method | Minimum loss |
|---|---|
| Evolutionary programming[28] | 5.0159 |
| Genetic algorithm[29] | 4.665 |
| Real coded GA with Lindex as SVSM[30] | 4.568 |
| Real coded genetic algorithm[31] | 4.5015 |
| Proposed IHPSO method | 4.2985 |

## VIII. Conclusion

In this paper, one of the recently developed stochastic algorithms IHPSO has been demonstrated and applied to solve optimal reactive power dispatch problem. The problem has been formulated as a constrained optimization problem. Different objective functions have been considered to minimize real power loss, to enhance the voltage profile. The proposed approach is applied to optimal reactive power dispatch problem on the IEEE 30-bus power system. The simulation results indicate the effectiveness and robustness of the proposed algorithm to solve optimal reactive power dispatch problem in test system.

## References Références Referencias

1. M. A. Abido, J. M. Bakhashwain, "A novel multiobjective evolutionaryalgorithm for optimal reactive power dispatch problem," in proc. Electronics, Circuits and Systems conf., vol. 3, pp. 1054-1057, 2003.
2. W. N. W. Abdullah, H. Saibon, A. A. M. Zain, K. L. Lo, "GeneticAlgorithm for Optimal Reactive Power Dispatch," in proc. EnergyManagement and Power Delivery conf., vol. 1, pp. 160-164, 1998.
3. K. Y. Lee, Y. M. Park, J. L. Ortiz, "Fuel-cost minimisation for both realandreactive-power dispatches," in proc. Generation, Transmission and Distribution conf., vol. 131, pp. 85-93, 1984.
4. S. Granville, "Optimal Reactive Dispatch Trough Interior PointMethods," IEEE Trans. on Power Systems, vol. 9, pp. 136-146, 1994.
5. N. I. Deeb, S. M. Shahidehpour, "An Efficient Technique for ReactivePower Dispatch Using a Revised Linear Programming Approach," Electric Power System Research, vol. 15, pp. 121-134, 1988.
6. N. Grudinin, "Reactive Power Optimization Using Successive QuadraticProgramming Method," IEEE

Trans. on Power Systems, vol. 13, pp. 1219-1225, 1998.
7. M. A. Abido, "Optimal Power Flow Using Particle SwarmOptimization," Electrical Power and Energy Systems, vol. 24, pp. 563-571, 2002.
8. A. A. Abou El Ela, M. A. Abido, S. R. Spea, "Differential EvolutionAlgorithm for Optimal Reactive Power Dispatch," Electric Power Systems Research, vol. 81, pp. 458-464, 2011.
9. V. Miranda, N. Fonseca, "EPSO-Evolutionary Particle SwarmOptimization, A New Algorithm with Applications in Power Systems," in Proc. of Transmission and Distribution conf., vol. 2, pp. 745-750,2002.
10. Geem Z (2006) Improved harmony search from ensemble of music players. In: Gabrys B, Howlett RJ, Jain L (eds) Knowledge-based intelligent information and engineering systems. Springer, Heidelberg, pp 86–93.
11. Geem Z (2007a) Optimal scheduling of multiple dam system using harmony search algorithm. In: Computationaland ambient intelligence. Springer, Berlin, pp 316–323.
12. C.A. Canizares, A.C.Z.de Souza and V.H. Quintana, "Comparison of performance indices for detection of proximity to voltage collapse,'' vol. 11. no.3, pp.1441-1450, Aug 1996.
13. C. M. Bishop. Neural Networks for Pattern Recognitionm. Oxford University Press, 1995.
14. T. Back, D.B. Foge, A. Michalewicz (Eds.). Handbook of Evolutionary Computation, IOP Publishers and Oxford University Press, 1997.
15. Holland J.H. Adaptation in Natural and Artificial Systems. MIT Press, 1975.
16. J. Kennedy, R. C. Eberhart. Swarm Intelligence. Morgan Kaufman, 2001.
17. A. P. Engelbrecht. Fundamentals of Computational Swarm Intelligence. John Wiley & Sons, 2005.
18. R. C. Eberhart, J. Kennedy, A new optimizer using particle swarm theory, in: Proceedings of the Sixth International Symposium on Micromachine and Human Science, Nagoya, Japan,1995,pp.39-43.
19. KENNEDY J, EBERHART R C. Particle swarm optimization[R]. Piscataway: Proceedings of IEEE International Conference on Neural Networks, NJ: IEEE Press, 1995.4: 1942-1948.
20. S.K.S. Fan, Y.C. Liang, E. Zahara. Hybrid simplex search and particle swarm optimization for the global optimization of multimodal functions. Engineering Optimization 36(4), 2004, pp. 401-418.
21. B.Liu, L. Wang, Y.H. Jin, F. Tang, D.X. Huang. Improved particle swarm optimization combined with chaos, Chaos Solitons & Fractals 25, 2005, pp. 1261-1271.
22. Z. W. Geem, J. H. Kim, G. V. Loganathan, A new heuristic optimization algorithm: harmony search, Simulation 76(2)(2001) 60-68.
23. K.S. Lee, Z.W. Geem, A new meta-heuristic algorithm for continues engineering optimization: harmony search theory and practice, Comput. Meth. Appl. Mech. Eng.194 (2004) 3902-3933.
24. J. H. Kim, Z. W. Geem, E.S. Kim. Parameter estimation of the nonlinear Muskingum model using harmony search. J.Am. Water Resour. Assoc. 37(5) (2001), pp.1131-1138.
25. Z. W. Geem, J. H. Kim, G. V. Loganathan. Harmony search optimization: application to pipe network design. Int.J.Model. Simul. 22(2) (2002), pp. 125-133.
26. S. L. Kang, Z. W. Geem. A new structural optimization method based on the harmony search algorithm. Comput. Struct.82 (9-10) (2004), PP. 781-798.
27. Z. W. Geem, C. Tseng, Y. Park. Harmony search for generalized orienteering problem: best touring in China, in: Springer Lecture Notes in Computer Science, vol. 3412, 2005, pp. 741-750.
28. Wu Q H, Ma J T. Power system optimal reactive power dispatch using evolutionary programming. IEEE Transactions on power systems 1995; 10(3): 1243-1248.
29. S. Durairaj, D. Devaraj, P. S. Kannan, 'Genetic algorithm applications to optimal reactive power dispatch with voltage stability enhancement', IE(I) Journal-EL Vol 87, September 2006.
30. D. Devaraj, 'Improved genetic algorithm for multi – objective reactive power dispatch problem' European Transactions on electrical power 2007; 17: 569-581.
31. P. Aruna Jeyanthy and Dr. D. Devaraj "Optimal Reactive Power Dispatch for Voltage Stability Enhancement Using Real Coded Genetic Algorithm" International Journal of Computer and Electrical Engineering, Vol. 2, No. 4, August, 2010 1793-8163.

# 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.

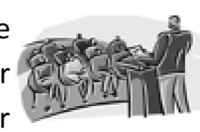
- The "FARSE" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSE or William Walldroff, M.S., FARSE.

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.

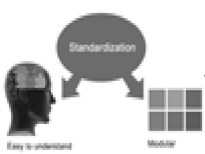


You may join as member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. In addition, it is also desirable that you should organize seminar/symposium/conference at least once.

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).

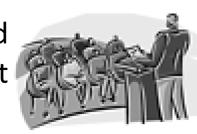
The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

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.

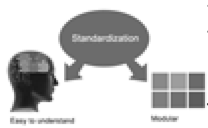


The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

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.

Global RESEARCH RADIO

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.

"

# Process of submission of Research Paper

The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

**(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.**

**(II) Choose corresponding Journal.**

**(III) Click 'Submit Manuscript'. Fill required information and Upload the paper.**

**(B) If you are using Internet Explorer, then Direct Submission through Homepage is also available.**

**(C) If these two are not conveninet , and then email the paper directly to dean@globaljournals.org.**

Offline Submission: Author can send the typed form of paper by Post. However, online submission should be preferred.

**MANUSCRIPT STYLE INSTRUCTION** **(Must be strictly followed)**

Page Size: 8.27" X 11'"

- Left Margin: 0.65
- Right Margin: 0.65
- Top Margin: 0.75
- Bottom Margin: 0.75
- Font type of all text should be Swis 721 Lt BT.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
- Abstract Font size of 9 Bold, "Abstract" word in Italic Bold.
- Main Text: Font size 10 with justified two columns section
- Two Column with Equal Column with of 3.38 and Gaping of .2
- First Character must be three lines Drop capped.
- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
- Numbering of Second Main Headings (Heading 2) must be in Alphabets, Italic, and Font Size of 10.

**You can use your own standard format also.**
**Author Guidelines:**

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

**1. GENERAL**

Before submitting your research paper, one is advised to go through the details as mentioned in following heads. It will be beneficial, while peer reviewer justify your paper for publication.

**Scope**

The Global Journals Inc. (US) welcome the submission of original paper, review paper, survey article relevant to the all the streams of Philosophy and knowledge. The Global Journals Inc. (US) is parental platform for Global Journal of Computer Science and Technology, Researches in Engineering, Medical Research, Science Frontier Research, Human Social Science, Management, and Business organization. The choice of specific field can be done otherwise as following in Abstracting and Indexing Page on this Website. As the all Global

Journals Inc. (US) are being abstracted and indexed (in process) by most of the reputed organizations. Topics of only narrow interest will not be accepted unless they have wider potential or consequences.

**2. ETHICAL GUIDELINES**

Authors should follow the ethical guidelines as mentioned below for publication of research paper and research activities.

Papers are accepted on strict understanding that the material in whole or in part has not been, nor is being, considered for publication elsewhere. If the paper once accepted by Global Journals Inc. (US) and Editorial Board, will become the copyright of the Global Journals Inc. (US).

**Authorship: The authors and coauthors should have active contribution to conception design, analysis and interpretation of findings. They should critically review the contents and drafting of the paper. All should approve the final version of the paper before submission**

The Global Journals Inc. (US) follows the definition of authorship set up by the Global Academy of Research and Development. According to the Global Academy of R&D authorship, criteria must be based on:

1) Substantial contributions to conception and acquisition of data, analysis and interpretation of the 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.

All authors should have been credited according to their appropriate contribution in research activity and preparing paper. Contributors who do not match the criteria as authors may be mentioned under Acknowledgement.

Acknowledgements: Contributors to the research other than authors credited should be mentioned under acknowledgement. The specifications of the source of funding for the research if appropriate can be included. Suppliers of resources may be mentioned along with address.

**Appeal of Decision: The Editorial Board's decision on publication of the paper is final and cannot be appealed elsewhere.**

**Permissions: It is the author's responsibility to have prior permission if all or parts of earlier published illustrations are used in this paper.**

Please mention proper reference and appropriate acknowledgements wherever expected.

If all or parts of previously published illustrations are used, permission must be taken from the copyright holder concerned. It is the author's responsibility to take these in writing.

Approval for reproduction/modification of any information (including figures and tables) published elsewhere must be obtained by the authors/copyright holders before submission of the manuscript. Contributors (Authors) are responsible for any copyright fee involved.

**3. SUBMISSION OF MANUSCRIPTS**

Manuscripts should be uploaded via this online submission page. The online submission is most efficient method for submission of papers, as it enables rapid distribution of manuscripts and consequently speeds up the review procedure. It also enables authors to know the status of their own manuscripts by emailing us. Complete instructions for submitting a paper is available below.

Manuscript submission is a systematic procedure and little preparation is required beyond having all parts of your manuscript in a given format and a computer with an Internet connection and a Web browser. Full help and instructions are provided on-screen. As an author, you will be prompted for login and manuscript details as Field of Paper and then to upload your manuscript file(s) according to the instructions.

To avoid postal delays, all transaction is preferred by e-mail. A finished manuscript submission is confirmed by e-mail immediately and your paper enters the editorial process with no postal delays. When a conclusion is made about the publication of your paper by our Editorial Board, revisions can be submitted online with the same procedure, with an occasion to view and respond to all comments.

Complete support for both authors and co-author is provided.

**4. MANUSCRIPT'S CATEGORY**

Based on potential and nature, the manuscript can be categorized under the following heads:

Original research paper: Such papers are reports of high-level significant original research work.

Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

**5.STRUCTURE AND FORMAT OF MANUSCRIPT**

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

**Papers**: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(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, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

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

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

**Format**

*Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.*

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

**Structure**

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive 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) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

*Abstract, used in Original Papers and Reviews:*

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

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

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin 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 research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

*Acknowledgements: Please make these as concise as possible.*

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

*Tables: Tables should be few in number, 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. Vertical lines should not be used.*

*Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.*

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. 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.

*Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.*

**6. AFTER ACCEPTANCE**

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

**6.1 Proof Corrections**

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

**6.2 Early View of Global Journals Inc. (US) (Publication Prior to Print)**

The Global Journals Inc. (US) are enclosed by our publishing's Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors' final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

**6.3 Author Services**

Online production tracking is available for your article through Author Services. Author Services enables authors to track their article - once it has been accepted - through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The authors will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript.

**6.4 Author Material Archive Policy**

Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

**6.5 Offprint and Extra Copies**

A PDF offprint of the online-published article will be provided free of charge to the related author, and may be distributed according to the Publisher's terms and conditions. Additional paper offprint may be ordered by emailing us at: editor@globaljournals.org .

You must strictly follow above Author Guidelines before submitting your paper or else we will not at all be responsible for any corrections in future in any of the way.

Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

## TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

**1. Choosing the topic:** In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

**2. Evaluators are human:** First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

**3. Think Like Evaluators:** If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

**4. 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.

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

**6. Use of computer is recommended:** As you are doing research in the field of Computer Science, then this point is quite obvious.

**7. Use right software:** Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

**8. Use the Internet for help:** An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

**9. Use and get big pictures:** Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

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

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

**12. Make all efforts:** Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

**13. Have backups:** When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

**14. Produce good diagrams of your own:** Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

**15. Use of direct quotes:** When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

**16. Use proper verb tense:** Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

**17. Never use online paper:** If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

**18. Pick a good study spot:** To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

**19. Know what you know:** Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

**20. Use good quality grammar:** Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

**21. 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 to your topic. You may also maintain your arguments with records.

**22. Never start in last minute:** Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

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

**24. Never copy others' work:** Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

**25. Take proper rest and food:** No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

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

**27. Refresh your mind after intervals:** Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

**28. Make colleagues:** Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

**29. Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

**30. Think and then print:** When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

**31. Adding unnecessary information:** Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

**32. Never oversimplify everything:** To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

**33. Report concluded results:** Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

**34. After 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 to 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 in 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 criterion for grading the final paper by peer-reviewers.

**Final Points:**

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of 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 the 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 evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

**Title Page:**

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

**Abstract:**

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing 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 approach 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. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than 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 maintain the initial two items to no more than one ruling each.

- Reason of the study - 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 quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness 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 to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled 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 with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose 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 sound written Procedures segment allows a capable scientist to replacement 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 for the least amount of information that would permit another capable scientist to spare 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 object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text 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:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not 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 - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in 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 a 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. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise 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 in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to 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 part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

**Discussion:**

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a 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 implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly 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 with prospect, and let it drop at that.

- Make a decision if each premise is supported, 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 the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One 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 available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

## Administration Rules Listed Before Submitting Your Research Paper to Global Journals Inc. (US)

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

**Segment Draft and Final Research Paper:** You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.
- Do not give permission to anyone else to "PROOFREAD" your manuscript.
- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

## CRITERION FOR GRADING A RESEARCH PAPER (COMPILATION)
## BY GLOBAL JOURNALS INC. (US)

**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 Inc. (US).**

| 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<br><br>Above 200 words | No specific data with ambiguous information<br><br>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