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

Global Journal of Researches in Engineering: F

Electrical and Electronic Engineering

Highlights

- Smart Solar Charge Controller
- Mitigation on Conducted Emission
- Application of Short-Term Load
- Performance Analysis of Enhanced

Discovering Thoughts, Inventing Future

VOLUME 17 ISSUE 2 VERSION1.0

© 2001-2017 by Global Journal of Researches in Engineering, USA

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

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 17 Issue 2 (Ver. 1.0)

Open Association of Research Society

© Global Journal of Researches in Engineering. 2017.

All rights reserved.

This is a special issue published in version 1.0 of "Global Journal of Researches in Engineering." By Global Journals Inc.

All articles are open access articles distributed under "Global Journal of Researches in Engineering"

Reading License, which permits restricted use. Entire contents are copyright by of "Global Journal of Researches in Engineering" unless otherwise noted on specific articles.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without written permission.

The opinions and statements made in this book are those of the authors concerned. Ultraculture has not verified and neither confirms nor denies any of the foregoing and no warranty or fitness is implied.

Engage with the contents herein at your own risk.

The use of this journal, and the terms and conditions for our providing information, is governed by our Disclaimer, Terms and Conditions and Privacy Policy given on our website http://globaljournals.us/terms-and-condition/menu-id-1463/.

By referring / using / reading / any type of association / referencing this journal, this signifies and you acknowledge that you have read them and that you accept and will be bound by the terms thereof.

All information, journals, this journal, activities undertaken, materials, services and our website, terms and conditions, privacy policy, and this journal is subject to change anytime without any prior notice.

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

Global Journals Inc.

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

Sponsors: Open Association of Research Society
Open Scientific Standards

Publisher's Headquarters office

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

Offset Typesetting

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

Packaging & Continental Dispatching

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

Find a correspondence nodal officer near you

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

eContacts

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

Pricing (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)

Editorial Board

Global Journal of Research in Engineering

Dr. Ren-Jye Dzeng

Professor
Civil Engineering
National Chiao-Tung University
Taiwan
Dean of General Affairs
Ph.D., Civil & Environmental Engineering
University of Michigan, USA

Dr. Eric M. Lui

Ph.D.,
Structural Engineering
Department of Civil
& Environmental Engineering
Syracuse University, USA

Dr. Ephraim Suhir

Ph.D., Dept. of Mechanics and Mathematics,
Moscow University
Moscow, Russia
Bell Laboratories
Physical Sciences and
Engineering Research Division, USA

Dr. Zhou Yufeng

Ph.D. Mechanical Engineering & Materials Science,
Duke University, US
Assistant Professor College of Engineering,
Nanyang Technological University, Singapore

Dr. Pangil Choi

Ph.D.
Department of Civil, Environmental, and Construction Engineering
Texas Tech University, US

Dr. Pallav Purohit

Ph.D. Energy Policy and Planning
Indian Institute of Technology (IIT), Delhi
Research Scientist,
International Institute for Applied Systems Analysis (IIASA), Austria

Dr. Iman Hajirasouliha

Ph.D. in Structural Engineering
Associate Professor,
Department of Civil and Structural Engineering,
University of Sheffield, UK

Dr. Zi Chen

Ph.D. Department of Mechanical & Aerospace Engineering,
Princeton University, US
Assistant Professor, Thayer School of Engineering,
Dartmouth College, Hanover, US

Dr. Wenfang Xie

Ph.D., Department of Electrical Engineering,
Hong Kong Polytechnic University,
Department of Automatic Control,
Beijing University of Aeronautics and Astronautics, China

Dr. Giacomo Risitano,

Ph.D., Industrial Engineering at University of Perugia (Italy)
"Automotive Design" at Engineering Department of Messina University (Messina) Italy.

Dr. Joaquim Carneiro

Ph.D. in Mechanical Engineering,
Faculty of Engineering,
University of Porto(FEUP),
University of Minho,
Department of Physics, Portugal

Dr. Hai-Wen Li

Ph.D., Materials Engineering
Kyushu University
Fukuoka
Guest Professor at Aarhus University, Japan

Dr. Wei-Hsin Chen

Ph.D., National Cheng Kung University
Department of Aeronautics
and Astronautics, Taiwan

Dr. Saeed Chehreh Chelgani

Ph.D. in Mineral Processing
University of Western Ontario,
Adjunct professor,
Mining engineering and Mineral processing
University of Michigan

Belen Riveiro

Ph.D.,
School of Industrial Engineering
University of Vigo, Spain

Dr. Bin Chen

B.Sc., M.Sc., Ph.D., Xi'an Jiaotong University, China.
State Key Laboratory of Multiphase Flow in Power Engineering
Xi'an Jiaotong University, China

Dr. Maurizio Palesi

Ph.D. in Computer Engineering,
University of Catania
Faculty of Engineering and Architecture
Italy

Dr. Cesar M. A. Vasques

Ph.D., Mechanical Engineering
Department of Mechanical Engineering
School of Engineering, Polytechnic of Porto
Porto, Portugal

Dr. Stefano Invernizzi

Ph.D. in Structural Engineering
Technical University of Turin,
Department of Structural,
Geotechnical and Building Engineering, Italy

Dr. T.S. Jang

Ph.D. Naval Architecture and Ocean Engineering
Seoul National University, Korea
Director, Arctic Engineering Research Center,
The Korea Ship and Offshore Research Institute,
Pusan National University, South Korea

Dr. Jun Wang

Ph.D. in Architecture, University of Hong Kong, China
Urban Studies
City University of Hong Kong, China

Dr. Salvatore Brischetto

Ph.D. in Aerospace Engineering, Polytechnic University of Turin and
in Mechanics, Paris West University Nanterre La Défense
Department of Mechanical and Aerospace Engineering,
Polytechnic University of Turin, Italy

Dr. Francesco Tornabene

Ph.D. in Structural Mechanics, University of Bologna
Professor Department of Civil, Chemical, Environmental and Materials Engineering
University of Bologna, Italy

Dr. Wesam S. Alaloul

B.Sc., M.Sc.,
Ph.D. in Civil and Environmental Engineering,
University Technology Petronas, Malaysia

Dr. Togay Ozbakkaloglu

B.Sc. in Civil Engineering
Ph.D. in Structural Engineering, University of Ottawa, Canada
Senior Lecturer University of Adelaide, Australia

Dr. Sofoklis S. Makridis

B.Sc(Hons), M.Eng, Ph.D.
Professor Department of Mechanical Engineering
University of Western Macedonia, Greece

Dr. Paolo Veronesi

Ph.D., Materials Engineering
Institute of Electronics, Italy
President of the master Degree in Materials Engineering
Dept. of Engineering, Italy

Dr. Ananda Kumar Palaniappan

B.Sc., MBA, MED, Ph.D. in Civil and Environmental Engineering,
Ph.D. University of Malaya, Malaysia
University of Malaya, Malaysia

Dr. Maria Daniela

Ph.D. in Aerospace Science and Technologies
Second University of Naples
Research Fellow University of Naples "Federico II", Italy

Dr. Zhen Yuan

B.E., Ph.D. in Mechanical Engineering
University of Sciences and Technology of China, China
Professor, Faculty of Health Sciences, University of Macau, China

Dr. Charles-Darwin Annan

Ph.D.,
Professor Civil and Water Engineering University Laval, Canada

Dr. Hugo Silva

Associate Professor
University of Minho
Department of Civil Engineering
Ph.D., Civil Engineering
University of Minho, Portugal

Dr. Stefano Mariani

Associate Professor
Structural Mechanics
Department of Civil
and Environmental Engineering,
Ph.D., in Structural Engineering
Polytechnic University of Milan, Italy

Dr. Jui-Sheng Chou

Ph.D. University of Texas at Austin, U.S.A.
Department of Civil and Construction Engineering
National Taiwan University of Science and Technology
(Taiwan Tech)

Dr. Shaoping Xiao

BS, MS
Ph.D. Mechanical Engineering, Northwestern University
The University of Iowa
Department of Mechanical and Industrial Engineering
Center for Computer-Aided Design

Dr. Fausto Gallucci

Associate Professor
Chemical Process Intensification (SPI)
Faculty of Chemical
Engineering and Chemistry
Assistant Editor
International J. Hydrogen Energy, Netherlands

Dr. Vladimir Gurao

Associate Professor
Ph.D. in Mechanical /
Aerospace Engineering
University of Miami
Engineering Technology

Prof. (LU) Prof. (UoS) Dr. Miklas Scholz

Cand Ing, BEng (equiv), PgC, MSc, Ph.D., CWEM, CEnv,
CSci, CEng,
FHEA, FIEMA, FCIWEM, FICE, Fellow of IWA,
VINNOVA Fellow, Marie Curie Senior Fellow,
Chair in Civil Engineering (UoS)
Wetland systems, sustainable drainage, and water quality

Dr. Adel Al Jumaily

Ph.D. Electrical Engineering (AI)
Faculty of Engineering and IT
University of Technology, Sydney

Dr. Houfa Shen

Ph.D. Manufacturing Engineering, Mechanical Engineering,
Structural Engineering
Department of Mechanical Engineering
Tsinghua University, China

Dr. A. Stegou-Sagia

Ph.D. Mechanical Engineering, Environmental
Engineering School of Mechanical Engineering
National Technical University of Athens

Dr. Kitipong Jaojaruek

B. Eng, M. Eng
D. Eng (Energy Technology, Asian Institute of
Technology).
Kasetsart University Kamphaeng Saen (KPS) Campus
Energy Research Laboratory of Mechanical Engineering

Dr. Jalal Kafashan

Mechanical Engineering
Division of Mechatronics
KU Leuven, BELGIUM

Dr. Haijian Shi

Ph.D. Civil Engineering
Structural Engineering
Oakland, CA, United States

Dr. Omid Gohardani

Ph.D. Senior Aerospace/Mechanical/
Aeronautical Engineering professional
M.Sc. Mechanical Engineering
M.Sc. Aeronautical Engineering
B.Sc. Vehicle Engineering
Orange County, California, US

Dr. Burcin Becerik-Gerber

University of Southern Californi
Ph.D. in Civil Engineering
DDes from Harvard University
M.S. from University of California, Berkeley
M.S. from Istanbul Technical University
Web: i-lab.usc.edu

Dr. Maciej Gucma

Asistant Professor, Maritime Univeristy of Szczecin
Szczecin, Poland
Ph.D.. Eng. Master Mariner
Web: www.mendeley.com/profiles/maciej-gucma/

Dr. Balasubramani R

Ph.D., (IT) in Faculty of Engg. & Tech.
Professor & Head, Dept. of ISE at NMAM Institute of Technology

Dr. Vivek Dubey(HON.)

MS (Industrial Engineering),
MS (Mechanical Engineering)
University of Wisconsin
FICCT
Editor-in-Chief, US
editorUS@globaljournals.org

Dr. Minghua He

Department of Civil Engineering
Tsinghua University
Beijing, 100084, China

Dr. Ye Tian

Ph.D. Electrical Engineering
The Pennsylvania State University
121 Electrical Engineering East
University Park, PA 16802, US

Dr. Diego González-Aguilera

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

Dr. Alex W. Dawotola

Hydraulic Engineering Section,
Delft University of Technology,
Stevinweg, Delft, Netherlands

Dr. Fentahun Moges Kasie

Department of mechanical & Industrial Engineering,
Institute of technology
Hawassa University Hawassa, Ethiopia

Dr. M. Meguellati

Department of Electronics,
University of Batna, Batna 05000, Algeria

Dr. Ciprian LĂPUȘAN

Ph. D in Mechanical Engineering
Technical University of Cluj-Napoca
Cluj-Napoca (Romania)

Dr. Zhibin Lin

Center for Infrastructure Engineering Studies
Missouri University of Science and Technology
ERL, 500 W. 16th St. Rolla,
Missouri 65409, US

Dr. Chao Wang

Ph.D. in Computational Mechanics
Rosharon, TX,
US

Dr. Shun-Chung Lee

Department of Resources Engineering,
National Cheng Kung University, Taiwan

Hiroshi Sekimoto

Professor Emeritus
Tokyo Institute of Technology, Japan
Ph.D., University of California, Berkeley

Dr. Philip T Moore

Ph.D., Graduate
Master Supervisor
School of Information
Science and engineering
Lanzhou University, China

Dr. Steffen Lehmann

Faculty of Creative and
Cultural Industries
PhD, AA Dip
University of Portsmouth, UK

Dr. Gordana Colovic

B.Sc Textile Technology, M.Sc. Technical Science
Ph.D. in Industrial management.
The College of Textile – Design, Technology and
Management, Belgrade, Serbia

Dr. Yudong Zhang

B.S., M.S., Ph.D. Signal and Information Processing,
Southeast University
Professor School of Information Science and Technology at
Nanjing Normal University, China

Dr. Xianbo Zhao

Ph.D. Department of Building,
National University of Singapore, Singapore,
Senior Lecturer, Central Queensland University, Australia

Dr. Philip G. Moscoso

Technology and Operations Management
IESE Business School, University of Navarra
Ph.D in Industrial Engineering and Management, ETH
Zurich
M.Sc. in Chemical Engineering, ETH Zurich
Link: Philip G. Moscoso personal webpage

Contents of the Issue

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 17 Issue 2 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Application of Short-Term Load Forecasting for Optimizing the Storage Devices of a Base Station

By Mishuk Mitra, Metali Rani Datta, Chinmoy Mallick & Atia Rahman
University of Asia Pacific (UAP)

Abstract- Energy is one of the important key factors to realize better socioeconomic development of a society and electrical energy is the most common form of energy for urban area both in commercials and residences. The instantaneous nature of electricity has made it different from other commodities as it has to be consumed just after the moment of generation. So, from generation parties to consumers at every stage of modern electricity grid it is every important to ensure the balance of consumption and production to achieve sustainability and reliability of the grid. Load forecasting is an important component for power system energy management system. Precise load forecasting helps the electric utility to make unit commitment decisions, reduces spinning reserve capacity and schedule device maintenance plan properly.

Keywords: artificial neural network (ANN), feed-forward neural network (FNN), renewable energy source (RES), photo voltaic (PV). base transceiver station (BTS), short term load forecasting (STLF), support vector machine (SVM), expert system (ES).

GJRE-F Classification: FOR Code: 090699

APPLICATIONOFSHORTTERMLOADFORECASTINGFOROPTIMIZINGTHESTORAGEDEVICESOFABASESTATION

Strictly as per the compliance and regulations of :

© 2017. Mishuk Mitra, Metali Rani Datta, Chinmoy Mallick & Atia Rahman. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecom mons.org/ licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Application of Short-Term Load Forecasting for Optimizing the Storage Devices of a Base Station

Mishuk Mitra [α], Metali Rani Datta [σ], Chinmoy Mallick [ρ] & Atia Rahman [Ѡ]

Abstract- Energy is one of the important key factors to realize better socioeconomic development of a society and electrical energy is the most common form of energy for urban area both in commercials and residences. The instantaneous nature of electricity has made it different from other commodities as it has to be consumed just after the moment of generation. So, from generation parties to consumers at every stage of modern electricity grid it is every important to ensure the balance of consumption and production to achieve sustainability and reliability of the grid. Load forecasting is an important component for power system energy management system. Precise load forecasting helps the electric utility to make unit commitment decisions, reduces spinning reserve capacity and schedule device maintenance plan properly. It also reduces the generation cost and increases reliability of power systems. In this work, an artificial neural network for short term load forecasting is demonstrated. Based on the time and similar previous day load, artificial neural network model is built, which are eventually used for the short-term load forecasting. The aim of this work is to describe the development and evaluation of a forecasting model to schedule the onsite storage devices. The evaluated model is able to predict the day-ahead electricity demand of a traditional base unit in order to schedule the storage devices.

Keywords: artificial neural network (ANN), feed-forward neural network (FNN), renewable energy source (RES), photo voltaic (PV). base transceiver station (BTS), short term load forecasting (STLF), support vector machine (SVM), expert system (ES).

I. Introduction

The process of achieving this research is mainly divided into two main parts: assessing the forecasting model and scheduling of storage device [1]. The modelling and simulation is performed in MATLAB.

a) Data pre-processing & Data-analysis

The function of the data pre-processing is acquiring representative data, removing unusual consumption hike and other inconsistencies, defining proper format for time stamping (day, month, hour, minute) and splitting up the data in identification and validation sets [2]. The function of the data analysis is analysing the data to find underlining mechanisms, trend and variations in the data, use of clustering to get more insight in intraday correlation [3].

b) Forecasting of Consumption & Storage Device Scheduling

To schedule the storage devices, it is very crucial to have prior knowledge about electricity consumption on day-ahead. Therefore, short-term forecasting is an important step to ensure better scheduling of the storage devices [4]. Pre-processed data is used to evaluate the performance of the forecasting models. Initially two forecasting models, ANN is chosen to forecast the consumption profile. This model is evaluated with respect to some evaluation criterion. The use of load forecasting is widely accepted as operational aid for the control the electric power system as well as to enhance consumer participation in local energy market through providing financial benefits.

The forecasted consumption profile of a base station will be used to achieve optimum scheduling of storage devices [5]. The main idea is to utilize the surplus of PV generated energy after mitigating self-consumption. If a particular consumer can have an idea about the level of stored energy, it is possible to utilize the energy in various way like, load shifting, include some flexible loads to consume the extra energy, valley filling etc. However, for this research our target is to feed the extra stored energy in local market, so that the consumer can have some financial benefits from the trading.

II. Methodology

The research approaches are selection and description of the electricity consumption data and the different variables, processing and detection of missing values, methods are discussed to discover the cohesion and pattern in the selected data and then procedure of evaluation is appointed [6].

a) Data

Real data of electricity consumption is needed for estimation and validation purposes of the forecasted result. Moreover, to predict the amount of stored energy in the storage devices on day-ahead, the PV generated energy of the corresponding base stations are also needed. As the ultimate goal is to predict the base

Author α: Department of Electrical and Electronic Engineering, University of Asia Pacific (UAP), Bangladesh.
e-mail: mitraeee@gmail.com

Global Journal of Researches in Engineering (F) Volume XVII Issue II Version I Year 2017

© 2017 Global Journals Inc. (US)

station forecasting, though additional Qualitative variables are introduced to recognize the precise pattern of the consumption behaviour of each consumer.

i. *Electricity Use Data*

Real energy consumption data of different BTS on a daily basis at 15 minutes of sampling is used. This data will be used to train the network and build the forecasted model. Then that forecasted model will be used to design the PV panel system and schedule the storage device [7]. All the data are taken in Wh and thus will be forecasted in the same unit.

a. *Normal Energy Consumption Data*

On average the yearly consumption of an identical base station in the Netherlands is 3500 kWh. So, daily electricity consumption on average is 9.5 kWh [37]. Consumption profile shown in the figure 2.1 is the electricity consumption pattern of a particular base station for the first week of March, 2013 with average consumption around 9 kWh per day.

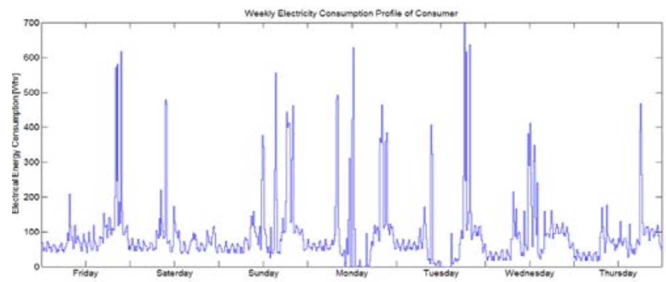


Figure 1: Weekly consumption pattern

However, the daily consumption patter in different depending on week days and weekend, even similar week days does not have similar consumption patterns shown in Figure 2.

It is very important to identify the non-linearity of the consumption pattern, because forecasting model selection is depend in the degree of non-linearity of the input data.

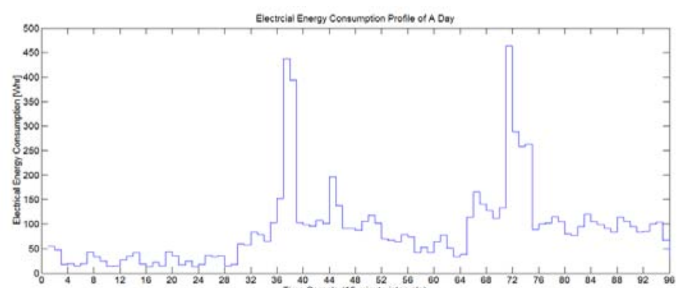


Figure 2: Daily load consumption

b. *Electrical Energy Consumption Compromised with PV*

After careful analysis, some data are found in the data set which follows a particular pattern but the average electricity consumption is less than the standard one. Figure 2.3 shows a consumption profile of a day which goes close to zero at mid-day [8]. Moreover, this particular base station has installed PV as local generation source. So, it is very much understandable this consumption profile is the net amount of energy consumed from grid after mitigating some load with PV. Thus, the electricity energy consumption data of this type of base stations cannot be used to identify the proper forecasting model.

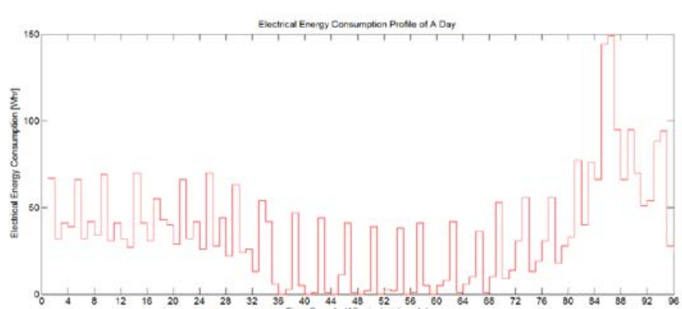


Figure 3: PV Compromised Electricity Consumption

© 2017 Global Journals Inc. (US)

Moreover, there are some consumption profile data sets with very low average daily consumption. A consumption profile of total 3.62 kWh is shown in Figure 4. At Figure4

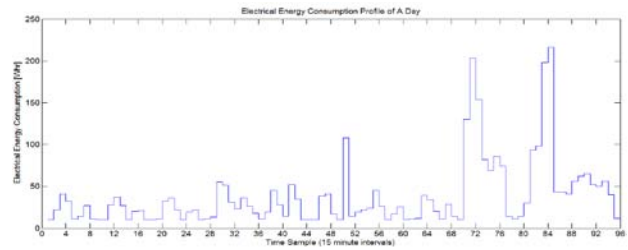


Figure 4: Electricity consumption of some particular equipment

Consumption is very low but at night it goes high. So most probably it is the consumption profile of cooling system. Though this consumption profile cannot give the proper idea about the consumer load behaviour.

ii. *Qualitative Variables*

Beside input variables (electrical energy consumption), also the qualitative variables are important for forecasting. Qualitative variables are better known as dummy variables; do not have a natural ordering. These variables contain descriptive values, like the day of the week. Moreover, all the data are 15 minute sampled so hour information is also a qualitative input variable. Depending on the time electrical consumption varies like at working days from 9.00AM to 6.00AM consumption should be low and at night when everybody is at home consumption goes high at base station. However, this hour based consumption pattern also depends on season. Thus, seasonal effect can be an input variable for forecasting. But this research is focused on STLF and to capture the consumer behaviour, electricity consumption data of two or three months is used as training data. So most of the case seasonal identification remains same for all training data. Finally, day identification along with our identification is considered as qualitative input variables for the forecasting model.

b) *Data Pre-processing*

Real life data contains huge amount of noise and often has quality issues. Such volatility must be removed before simulation can be performed. If the input values to a forecasting model are poor, it will be hard to produce a good forecast, irrelevant of the quality of the forecast model. All the steps has to be taken into consideration before simulation as pre-processing is given below

- Duplicate data check
- Missing data check
- Filtering unusual and noise from PV generation data set

Duplicate and Missing Data check:

The electricity consumption data of different base station of a year is given as Wh/15 min. Smart meters are used as measuring device, thus it has high possibility of missing data and duplicate data. Initially the full data set is passed through some checking algorithm to identify duplicate data and missing data as Pre-processing step. However, data with same time stamp is treated as duplicate data. For missing data on weekdays, average value of the immediate 7 weekday's consumption data on the same time sample is taken. However missing data for weekend days, average consumption of the previous 4 same days on the same time sample is calculated.

As an example, to find a missing data on weekdays at y_t it should take the average of previous seven weekdays on the same time t shows in Figure 5.

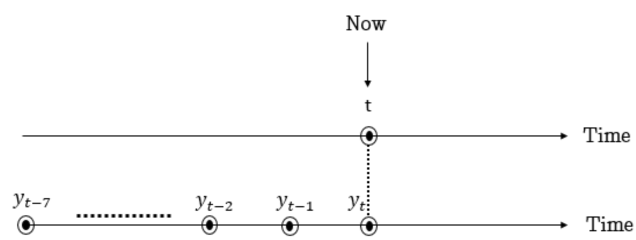


Figure 5: Average value for missing data on weekdays

Moreover, to find a missing data on weekend (as an example Saturday) it has to take the average of previous 4 Saturday of the same time sample shown in Figure 2.6.

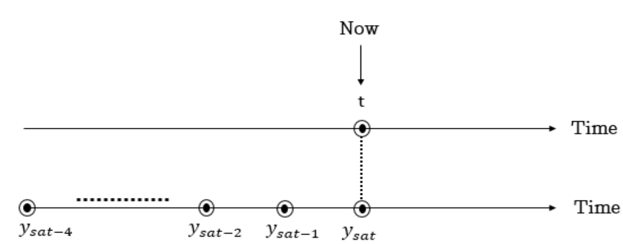


Figure 6: Average value for missing data on weekend

Filtering unusual and noise from PV generation data set:

The PV generated data is also measured in 15-minute interval but it is very important to identify the noise or unusual production. Normally electronics based measurement devices are used to capture the data from controller [38]. So, to have unusual production peak or noise (like production level 1 or 2Wh) is very common.

© 2017 Global Journals Inc. (US)

Moreover, synchronize PV production and consumption data for the same consumer is also important for scheduling of stage device.

c) Data Analysis

i. Day identification Number as Input of ANN

It is very important to make some difference among the different days of the week so that the models can identify the target data set according to the train data set. Initially these identification variables are coded into integer value. The days of the week is represented by 1,2,3,4,5,6,7 respectively for Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday.

Correlation or patterns within the electricity use can aid the forecast if well defined. To discover patterns in the electricity use, self-organizing map (SOM) is used [9]. The motivation behind SOM analysis is to find the pattern of consumption of each day of a week. SOM clustering of seven days of a week is shown in Figure 2.7.

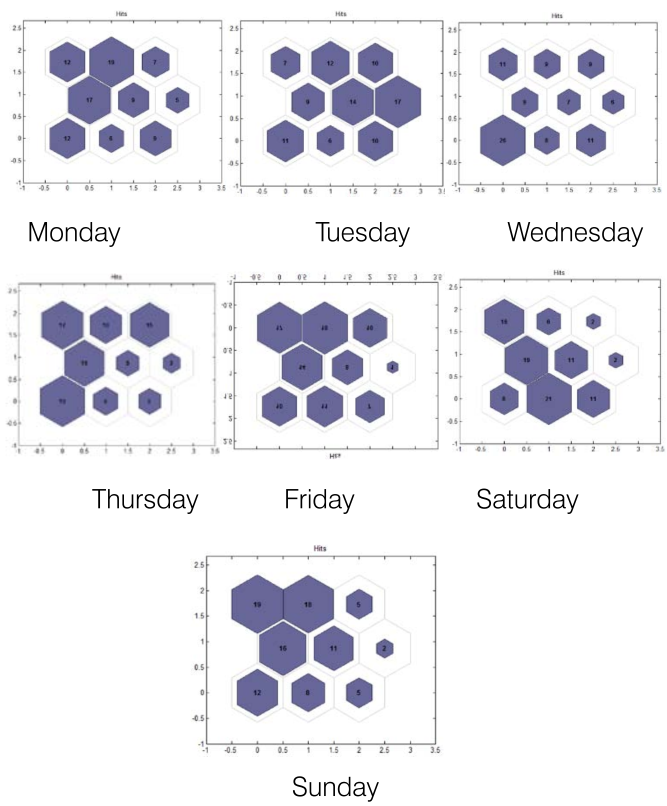


Figure 7: SOM clustering of electricity use per day

Figure 2.7 illustrates different electricity consumption pattern of each day. So, as an input of ANN day identification number will be different for each day.

d) Evaluation Method

An evaluation method is necessary for three aspects;

- Model identification
- Performance comparison between models
- Insight in model performance for practical use

In order to evaluate a forecast made with a specific model, forecast-error metrics or so called performance indicators are defined. Three types of performance indicators are discussed. The first used performance indicators are the scale dependent metrics. These indicators are on the same scale as the data. One of the most used scaled performance indicator is the mean are extremely large when the actual values reaches zero [10]. When considering data which contain zeros, the metric is undefined. An example of percentage based metric is the MAPE, which is one of the most used squire error (MSE). The other category is percentage based performance indicators, which can be used to compare different data sets as they are scale independent. To overcome division by zero, a scale free error is proposed by Hyndman and Koehler in 2006 [40]. The above-mentioned performance indicators are given below.

In each of the forthcoming definitions y_t is actual value, f_t is the forecasted value, $e_t = y_t - f_t$ is the forecast error and n is the size of the test set. Also, $\bar{\mathrm{y}} = \frac{1}{\mathrm{n}}\sum_{\mathrm{t}=1}^{\mathrm{n}} \mathrm{y}_\mathrm{t}$ is the test mean and $\sigma^2 = \frac{1}{\mathrm{n}-1}\sum_{\mathrm{t}=1}^{\mathrm{n}}(\mathrm{y}_\mathrm{t} - \bar{\mathrm{y}})^2$ is the test variance.

© 2017 Global Journals Inc. (US)

i. *The Mean Squire Error (MAE)*

The mean absolute error is defined as [41] [42]

$$\mathrm{MSE} = \frac{1}{\mathrm{n}}\sum_{\mathrm{t}=1}^{\mathrm{n}} (\mathrm{e_t})^2 \qquad \text{(a)}$$

Its properties are –

- It measures the average absolute deviation of forecasted values from original ones.
- It shows the magnitude of overall error, occurred due to forecasting.
- In MSE, the effects of positive and negative errors are canceled out.
- For a good forecast, the obtained MSE should be as small as possible.
- Extreme forecast errors are not panelized by MSE.

ii. *The Mean Absolute Percentage Error (MAPE)*

This measure is given by [41] [43]

$$MAPE = \frac{1}{n}\sum_{t=1}^{n} \left| \frac{e_t}{y_t} \right| \times 100\,\% \qquad \text{(b)}$$

Its important features are:

- This measure represents the percentage of average absolute error occurred.
- It is independent of the scale of measurement, but affected by data transformation.
- It does not show the direction of error.
- MAPE does not panelize extreme deviations.
- In this measure, opposite signed errors do not offset each other.

III. Model Building

a) ANN based Forecasting Model

Artificial neural networks (ANNs) constitute a class of flexible nonlinear models designed to mimic biological neural systems of brain. Typically, a biological neural system consists of several layers, each with a large number of neural units (neurons) that can process the information in a parallel manner as illustrated in Figure 3.1. Like biological neuron, ANN has also multi-layer structure such that the middle layer is built upon many simple nonlinear functions and able to receive multiple input signals from other neurons. The procedure of selecting optimal network architectures and their learning approaches are described for forecasting the wind speed in two different time horizon [11][13].

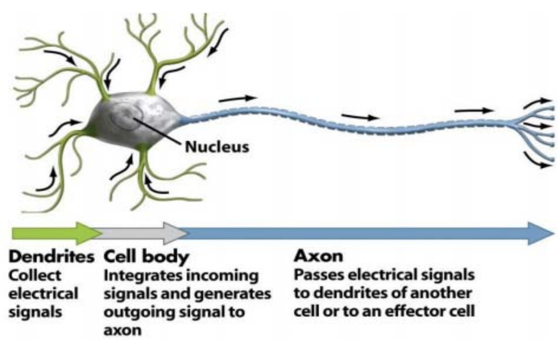


Figure 8: Flow of information in biological neuron.

b) Working Principle of Forecasting Model

ANNs are networks typically composed of several layers with interconnected elements called neurons. The first or lowest layer is the input layer which gathers external information. The middle or hidden layers process this information in a fairly elementary way to produce signals for the connected neurons at output layer. The neurons or nodes at the adjacent layers are usually fully connected by acyclic arcs from a lower layer (input) to a higher layer (output).

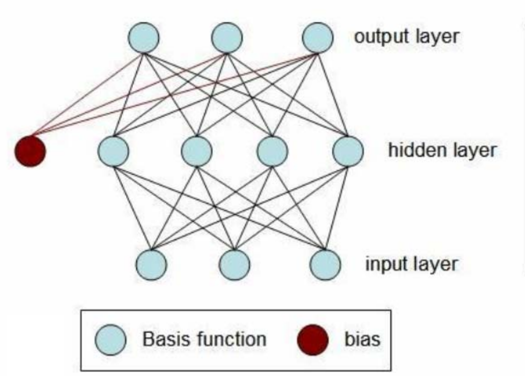


Figure 9: A general ANN structure with one hidden layer

Input values are processed by this network to form output values as depicted in a simple non-linear

© 2017 Global Journals Inc. (US)

model, the inputs are independent variables. The functionality estimated by the ANN can be written as:

$$y1, y2, \ldots, yn = f(x1, x2, \ldots, xn)$$

Where, x1,x2,……,xn are independent input variables and y1,y2,…… ,yn are dependent output variables.

Weights are the key factors of network performance. These weights are continuously updated during the training period to carry out complex non-linear mapping [12]. In this research the developed forecasting model is trained in supervised way. Once the network is trained with appropriate training data set, it is ready to perform desire task.

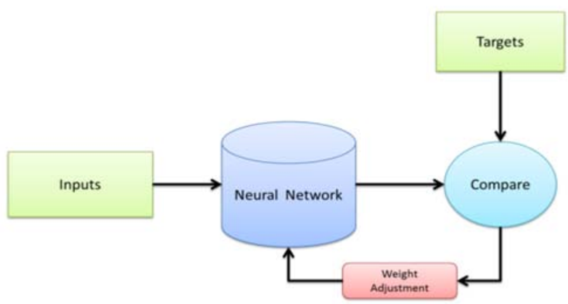


Figure 10: Illustration of network weights in supervised learning process

c) Network Architecture

Complicacy of ANN mainly arises for the hidden layers which are used to build the connection between inputs and outputs. Thus, it creates an indirect relationship between inputs and outputs. Information received from the input layer is first processed in the hidden layer, and then transmitted to the output layer. So, the learning capability due to nonlinearity of the input data is mostly depend on number of hidden layers. A multilayer forecasting model with one hidden layer can perform an arbitrary convex approximation to any continuous non-linear mapping. According to the universal approximation theorem for neural networks [49], the standard multilayer feed forward network with a single hidden layer and finite number of hidden neurons is sufficient for any complex simulate nonlinear function with any desired accuracy. It concludes with the view that number of hidden layers has an influence according to the complicacy of the problem otherwise system will be more complicated, even single hidden layer requires large number of nodes. So, it is always a tradeoff of number of hidden layers depending on complicacy of the problem.

d) Selection of the Network

Depending on the structure of the network ANN can be classified in several models. Figure 3.4 shows different types of neural networks used for forecasting applications.

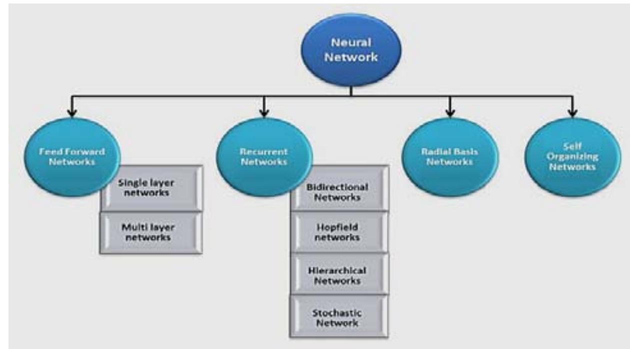


Figure 11: The taxonomy of ANN architecture

Feed-forward neural network (FNN) is fast and simplest ANN because in the case of Multilayer layer network it transmits information form input layer to output layer using some simple structured hidden layer [13]. Normally it maps the static relationship between input and outputs

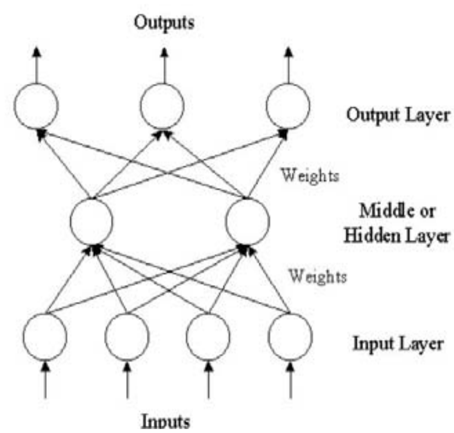


Figure 12: Structure of FNN

through a unidirectional information flow (only form input towards output). The inputs are fed directly to the outputs via a series of weights. Each connection may have different weights. Due to lack of any feedback, FNN must use a large number of input neurons for learning the historical data and consequently achieving good results. Despite of being simple, feed-forward networks are more efficient in complex nonlinear forecasting problem with bigger number of input variables [15].

e) Mathematical Model

In a mathematical model, has been developed referring to the Figure 3.5

$$\boldsymbol{y_t = a_0 + \sum_{j=1}^{q} a_j\, g\left(\beta_{0j} + \sum_{i=1}^{p} \beta_{ij} y_{t-i}\right) + \varepsilon_t\,, \forall\, t}$$

Here $\boldsymbol{y_{t-i}}$ $(\boldsymbol{i = 1, 2, 3, \ldots. p})$are the input and $\boldsymbol{y_t}$ is the output. The integers $\boldsymbol{p}$ ***and*** $\boldsymbol{q}$ are the number of input and hidden nodes respectively. $\boldsymbol{a_j\,(j =}$

© 2017 Global Journals Inc. (US)

$1,2,3,\ldots\ldots q$) and $\beta_{ij} = (i = 1,2,3,\ldots\ldots p; j = 1,2,3,\ldots\ldots q)$ are the connection weights and ε_t is the random variable, a_0 , β_0 are the bias term. Usually, the logistic sigmoid function $g(x) = \frac{1}{1+e^{-x}}$ is applied as the nonlinear activation function. Other activation functions, such as linear, hyperbolic tangent, Gaussian, etc. can also be used depending upon the use case.

The feed forward ANN model in Equation 1 in fact performs a non-linear functional mapping from the past observations of the time series to the future value, i.ey_t=f (y_(t-1),y_(t-2) 〖,y〗 _(t-3),……y_(t-p) ,W)+ ε_t where Wa vector of all parameters is and f is a function determined by the network structure and connection weights [15]

To estimate the connection weights, non-linear least square procedures are used, which are based on the minimization of the error function

$$F(\varphi) = \sum_t e_t^2 = \sum_t (y_t - \hat{y}_t)^2$$

Here φ is the space of all connection weights. The optimization techniques used for minimizing the error function Equation 2 are referred as Learning Rules. The best-known learning rule in literature is the back propagation or Generalized Delta Rule.

IV. Simulation Results and Analysis

The optimal structure of ANN is used to forecast the BTS electricity consumption on day-ahead. In this case 31st of October, 2012 is considered for the demonstration of the model. The imbalance power is calculated by the power deviation between day-ahead forecaster and 15 minutes ahead forecaster. The flexible entities are activated in way to reduce this imbalance power. A simple MATLAB-based GUI has been implemented to demonstrate how this tool can be user-friendly for a customer.

a) Assumptions

The historical data are in Wh and the time interval is 15 minutes. As input, total 92 days of previous data is taken for pre-processing [14][15].The time range is March 1st, 2013 to May 31st 2013. The forecasted data represents the consumption for the next day, June 1st 2013.

b) Electricity Consumption Forecasting

i. Model of Feed-Forward ANN

Designing a three-layer FNN model for STLF involves several major steps:

1) Determine the number of outputs: An FNN model may have only one output, which can be corresponding to the electrical load of a consumer, or several outputs, which can represent a 24-hour load profile of several BTSs. Some drawbacks of the multiple outputs FNN were discussed in [26].
2) Determine the number of inputs: previous consumption data of a particular consumer along with day identification number is used as target and input of FNN.
3) Determine the number of hidden neurons: It is followed a trial and error method to select an optimal hidden layer structure for used data set at FNN. The number of hidden neuron layer mostly depends on: MAPE, Elapsed Time & Epoch.

The lowest MAPE, lowest time and highest Epoch is found for the chosen number of layer. Observing these parameters, the best output is obtained from 25 hidden layer amongst different options.

ii. Consumption forecasting on mid-summer (June 01, 2013)

Practical consumption data from 30 BTS will be used to evaluate the forecasting performance of the models. In this context, at first it is tried to forecast the consumption profile of each consumer on the same day with training data set of previous 3 months (92 days).

Table 1: FNN Evaluation

Consumer	ANN		
	R	MSE	MAPE (%)
1	0.94285	3.63E+03	33.9695
2	0.89787	1.26E+04	39.39
3	0.78771	8.70E+03	28.5366
4	0.91719	1.49E+03	52.8844
5	0.83974	572.452	15.9883
6	0.41161	440.1884	103.0053
7	0.97297	1.27E+03	47.334
8	0.91181	343.6435	25.3231
9	0.9641	1.23E+03	26.5852
10	0.9468	537.9639	27.9004

© 2017 Global Journals Inc. (US)

11	0.8576	4.71E+03	52.6619
12	0.85425	3.95E+03	79.4627
13	0.85881	281.4154	227.0793
14	0.90321	805.5652	40.9806
15	0.9535	1.71E+03	42.787
16	0.90626	1.01E+04	43.5497
17	0.93196	2.39E+03	19.4287
18	0.82326	6.87E+03	20.21
19	0.9188	2.71E+03	46.3432
20	0.94752	9.59E+03	18.249
21	0.94696	914.3805	53.9584
22	0.91646	1.04E+04	20.6975
23	0.93604	2.93E+03	40.1062
24	0.95008	1.97E+03	114.3078
25	0.85898	5.49E+03	72.9944
26	0.91428	1.92E+03	68.4901
27	0.87358	5.23E+03	28.0127
28	0.93541	2.10E+03	20.6213
29	0.84505	519.5149	626.8921
30	0.88409	1.45E+03	19.0804

a. *Forecasting with FNN*

Form Table 1, it can be mentioned that FNN performed well. Some out of range data is found in MAPE which happened because those consumers had no usage of electricity in their consumer profile at some hours of the day. Considering the case of MAPE, site 5 has the best output as 15.9883%. Consumer 5 has a moderate level of error (MSE = 572.452) and a very noticeable regression mismatch as it is far away from 1 (R=0.83974)

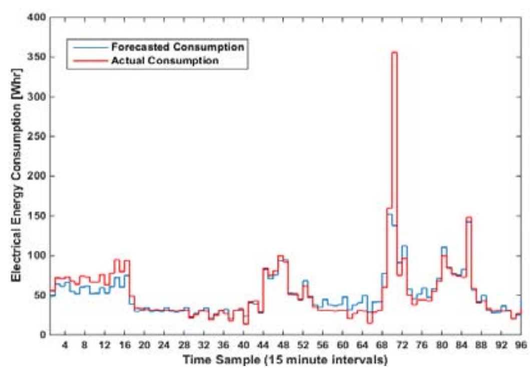


Figure 13: Forecasting performance of FNN for site 5

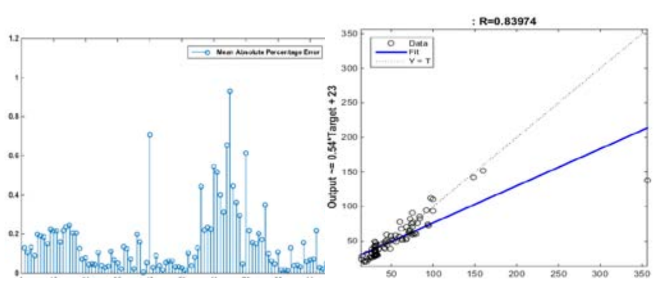


Figure 14: MAPE and R of forecasted output of site 5 by FNN

In Figure 4.2, the regression function and MAPE for the consumer is shown. The dotted line in the regression represents the exact result and the solid line represents the best fit regression line between the input and the output. The main reason for this deflection is for changing the behavior of the consumer at that particular time.

© 2017 Global Journals Inc. (US)

Lest MSE belongs to consumer 8 (MSE=343.6435). But the percentage error is as high as MAPE=25.3231%. In Figure 6-3 it is clearly visible that the output profile almost followed the trend. And most of the points are well predicted, though many of them are lower than the actual data

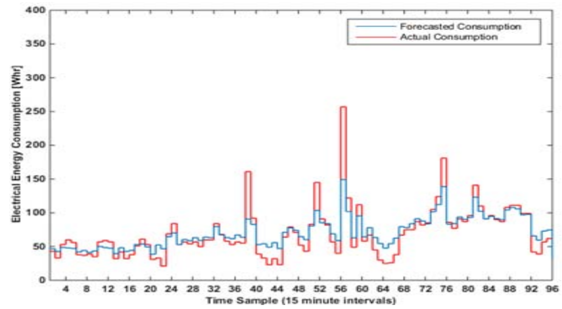


Figure 15: Forecasting performance of FNN for site 8

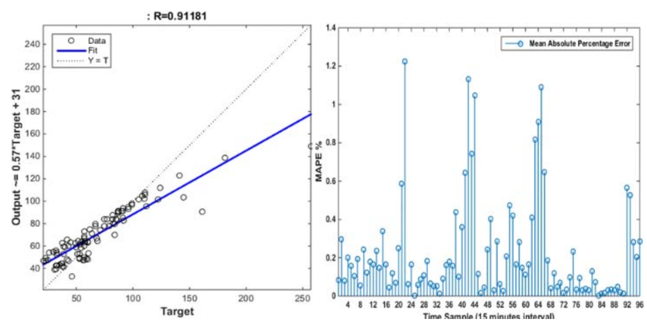


Figure 16: MAPE and R of forecasted output of site 8 by FNN

Figure 6-4, obtained regression function is comparatively good. The mismatched area lies in between 50 to 100Wh and the MAPE shows a scattered pattern of error. Moreover it is clear that the errors largely occurred at the peaks.

Finally, another consideration is done for other consumer for optimized evaluation. In this case the overall performance has been considered. The selected one is being consumer 2. For the selected consumer, R=0.8978; MSE=1260; MAPE=39.39. Though the R is obtained parameters are at moderate level as slightly mismatched from the ideal value, MAPE has been obtained in an acceptable range. But the MSE is so large that can affect the overall performance of the forecasting model.

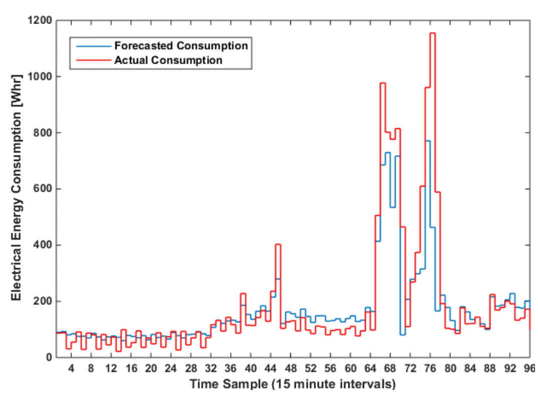


Figure 17: Forecasting performance of FNN for site 2

From the Figure 4.5, the forecasted data is matched in almost every point with the actual consumption profile. The major mismatch is found at the higher peaks. Though the forecasted model has followed and detected the positions of the peaks well, but the values estimated are lower than the actual consumption. This mainly happens for the change in the consuming behaviour of the consumer.

The regression function plotting is lineated based on the best points to be found. The most mismatching is found around 100 to 300Whr. Noticeable percentage errors are found at the peaks from the scattered plotting.

© 2017 Global Journals Inc. (US)

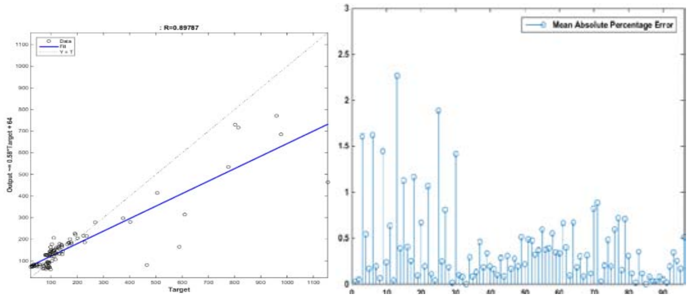


Figure 18: MAPE and R of forecasted output of site 2 by FNN

c) *Scheduling*

Based on the forecasted model, scheduling of the BTS storage device is designed and operated. For this research two ideal profiles are chosen. For the betterment of the demonstration, the available energy is compared with both actual consumption profile and the forecasted consumption profile.

For the demonstration consumer 2 is chosen. Figure 4.7 shows the scheduling of a storage device with the actual consumption profile. From the figure, available energy and stored energy is utilized in a balanced way. During the mid-hour of the day, amount of the available and stored energy is adequate. And the individual BTS has used the stored energy to meet its requirements.

The PV rating, in this case, is 7.5KW. So, the figure below clears out that, the consumer is using around 400W. That means, he can schedule the storing of the device a day ahead to save the rest 7.1KW of energy [16].

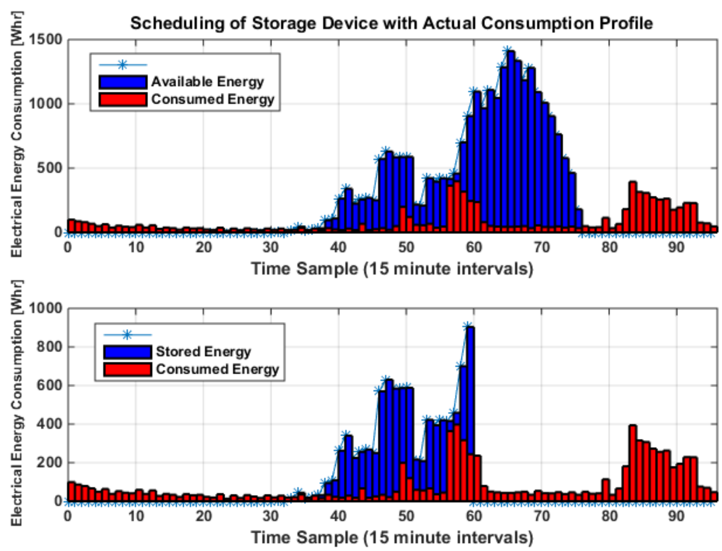


Figure 19: PV production and available energy for site 2

Forecasted consumption profile demonstrates the typical scheduling for the device. This is to determine the charging time of the storage device at the day ahead and to be aware of the amount of the energy to be used. From the figure 4.8, the needed energy for the next day can be estimated. It will be used to determine the time to store the energy and the dissipating time of the power. And based on the forecasted model, stored energy can be used to make the BTS grid free user. Thus a BTS can be grid independent and produce, store and consume its own energy.

© 2017 Global Journals Inc. (US)

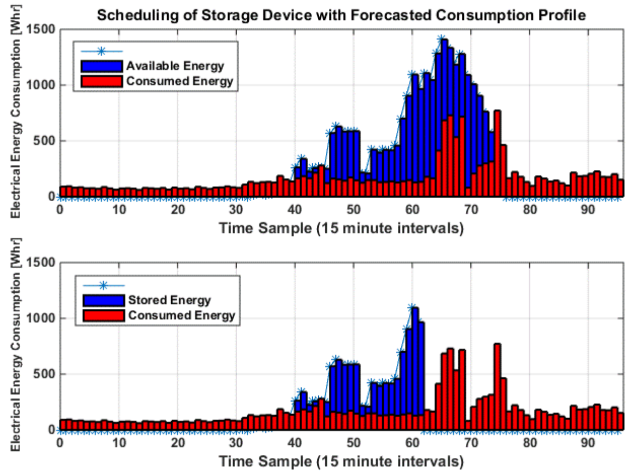


Figure 20: Storage device scheduling using FNN forecasted consumption profile

For further evaluation, consumption model of another consumer is illustrated in Figure 4.9, 4.10 that demonstrates the same scenario for consumer 17. That means, this profile will help the consumer to schedule, store and use the energy for its own.

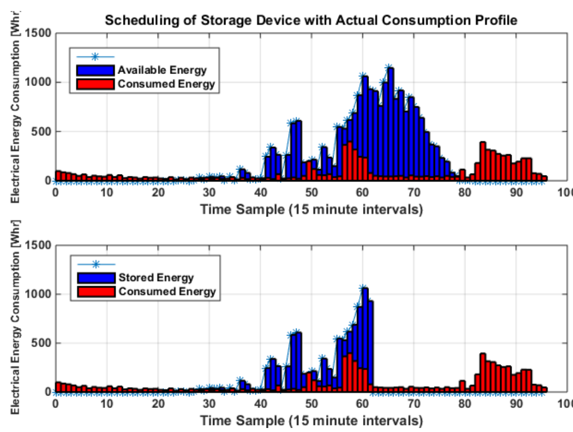


Figure 21: PV production and available energy for site 17

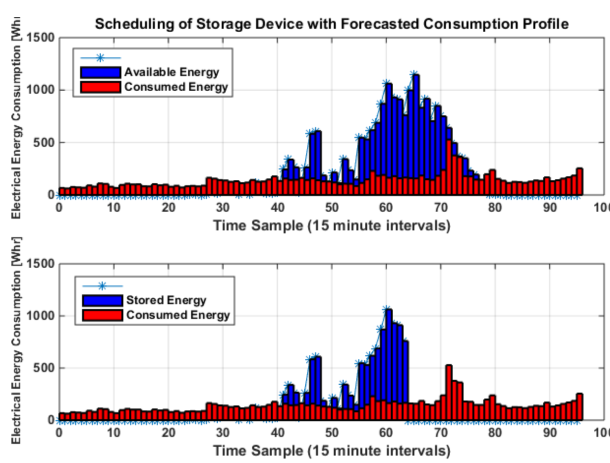


Figure 22: Storage device scheduling using FNN forecasted consumption profile

© 2017 Global Journals Inc. (US)

V. Conclusion & Future Work

The main focus of this research work was to identify and justify a optimized forecasting model to forecast the electricity consumption at BTS and comparing the results on the basis of the major error measurement parameters and establishing a reliable and most accurate FNN forecasting model. The forecasted data can be used for designing the scheduling and designing the independent power source for the BTS. This will help the consumer to use its own power to meet its requirement. Thus, it can become grid free consumer.

However, the following recommendations are suggested for improving the forecaster.

Instead of using Levenberg-Marquardt algorithm; which is computationally heavy; another learning method called Scaled Conjugate Gradient (SCG) for bigger ANN approximation and prediction. Larger iteration number of hidden neurons is preferable for finding optimum solution. In STLF, ARIMA is proved as a poor forecaster because of having a significant level of non-linearity in historical data. However, a hybrid model combined with ANN and ARIMA is needed to be investigated. The input variables for the forecasting model should be selected based on partial mutual information (PMI) algorithm instead of the last known research experience only. This method will detect non-linear dependencies between the input and output as well as prevent the selection of inputs with redundant information. It will reduce the dimension of the input layer. Aside of using Neural Network Toolbox™ of MATLAB, better flexibility would be expected. Thus, the user will have more control on every step of the program.

References Références Referencias

1. Short-Term Load Demand Modeling and Forecasting: A Review. Abu-El-Magd, Mohamed A. and Sinha, Naresh K. 03, 1982, IEEE Transactions on Systems, Man, and Cybernetics, Vol. 12, pp. 370-382.
2. http://www.cs.ccsu.edu/~markov/ccsu_courses/datamining-3.html
3. https://ori.hhs.gov/education/products/n_illinois_u/datamanagement/datopic.html
4. Forecasting the Demand for Electricity in Saudi Arabia. Al-Sahlawi, Mohammed A. 1, 1990, The Energy Journal, Vol. 11, pp. 119-125.
5. Gellings, Clark W. and Barron, Wallace L. Demand Forecasting for Electric Utilities. s.l. : Fairmont Press, 1992.
6. Short term electric load forecasting: A tutorial. Kyriakides, E. and Polycarpou, M. s.l. : Trends in Neural Computation, Studies in Computational Intelligence, 2007, Trends in Neural Computation, Studies in Computational Intelligence, Springer, Vol. 35, pp. 391-418. (Chapter 16).
7. Long-term electricity demand in China — From quantitative to qualitative growth? Hirschhausen, Christian von and Andres, Michael. 4, April 2000, Energy Policy, Elsevier, Vol. 28, pp. 231–241.
8. Choynowski, Peter. Measuring Willingness to Pay for Electricity. s.l. : Economics and Research Department, Asian Development Bank, July 2002. ERD Technical Notes.
9. Analysis and evaluation of five short-term load forecasting techniques. Moghram, Ibrahim and Rahman, Saifur. 4, 1989, Power Engineering Review, IEEE Journal and Magazines, Vol. 4, pp. 42-43.
10. Analysis and evaluation of five short term load forecasting techiniques. Moghram, I. and Rahman, S. 1989, IEEE Transaction s on Power, Vol. 4, pp. 1484-1491.
11. Application of Neural network Model Combining Information Entropy And Antcolonyclustering Theory for Short-Term Load Forecasting. Sun, Wei, et al., et al. Guangzhou : s.n., 2005. Fourth International Conference on Machine Learning and Cybernetics. pp. 18-21.
12. Electric load forecasting: Literature survey and classification of methods. Nazeeruddin, Hesham K and Mohammad, Alfares. 2010, International Journal of Systems Science, Vol. 33, pp. 23-34.
13. Artificial neural network methodology for short term load forecasting. Lee, K, Cha, Y and Park, J. 1990, NSF Workshop on Artificial Neural Network Methodology in Power System Engineering, Clemson University.
14. An Adaptive Data Processing System for Weather Forecasting. Hu, M J C and Root, H E. 5, 1964, Journal of Applied Meteorology, Vol. 3, pp. 513-523.
15. Seasonal Time Series Forecasting: A Comparative Study of ARIMA and ANN Models. Kihoro, J.M., Otieno, R.O. and Wafula, C. 2, 2004, African Journal of Science and Technology (AJST) Science and Engineering Series, Vol. 5, pp. 41-49.
16. Performance parameters for grid-connected PV systems. Marion, B., et al., et al. 2005, Photovoltaic Specialists Conference, 2005. Conference Record of the Thirty-first IEEE, pp. 1601 - 1606.
17. Feedforward Versus Recurrent Neural Networks For Forecasting Monthly Japanese Yen Exchange Rates. Dematos, G., et al., et al. 1, 1996, Financial Engineering and the Japanese Markets, Vol. 3, pp. 59-75.
18. Lee, J. Univariate time series modeling and forecasting (Box-Jenkins Method). s.l. : Econ 413, Lecture 04 .

© 2017 Global Journals Inc. (US)

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 17 Issue 2 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Design and Construction of a Microcontroller based Smart Solar Charge Controller for Automatic Brightness Controlling of PV based Street Light

By Tahmid Hasan Rupam, Farhana Jesmin Tuli, & Md. Habibur Rahman
University of Dhaka

Abstract- Bangladesh being an over-populated country needs to produce a huge amount of energy to meet its people's demands. On the other hand, it is quiet impossible to provide the large population with adequate energy with the conventional way of producing energy. Only 62% of our people have the privilege of using electricity. So apart from finding cost effective ways to harness energy, it is required to use the produced energy efficiently. This paper aims to find a way to reduce the pressure on grid energy by empowering the street lights using solar panels. In this regard, it also focuses on having a smart charge controller circuit for ensuring battery longevity. Here PIC16F876A microcontroller has been used to sense different voltage levels and make decisions according to them..

Keywords: solar PV module, PIC microcontroller, LDR sensor, ON/OFF smart solar charge controller, LED street lights, automatic brightness control etc.

GJRE-F Classification: FOR Code: 090605

DESIGNANDCONSTRUCTIONOFAMICROCONTROLLERBASEDSMARTSOLARCHARGECONTROLLERFORAUTOMATICBRIGHTNESSCONTROLLINGOFPVBASEDSTREETLIGHT

Strictly as per the compliance and regulations of:

© 2017. Tahmid Hasan Rupam, Farhana Jesmin Tuli, & Md. Habibur Rahman. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecom mons.org/ licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Design and Construction of a Microcontroller based Smart Solar Charge Controller for Automatic Brightness Controlling of PV based Street Light

Tahmid Hasan Rupam [α], Farhana Jesmin Tuli [σ], & Md. Habibur Rahman [ρ]

Abstract- Bangladesh being an over-populated country needs to produce a huge amount of energy to meet its people's demands. On the other hand, it is quiet impossible to provide the large population with adequate energy with the conventional way of producing energy. Only 62% of our people have the privilege of using electricity. So apart from finding cost effective ways to harness energy, it is required to use the produced energy efficiently. This paper aims to find a way to reduce the pressure on grid energy by empowering the street lights using solar panels. In this regard, it also focuses on having a smart charge controller circuit for ensuring battery longevity. Here PIC16F876A microcontroller has been used to sense different voltage levels and make decisions according to them. The CCP module of the microcontroller has been used for a variable duty cycle PWM signal to adjust the brightness of the LED street lights according to necessity. The intensity of the street light will be automatically adjusted and will go OFF in the morning. By the use of LED street lights the reduction of the consumption of energy has been ensured. Apart from this, the smart solar charge controller can also be used for the electrification of remote places using solar energy as it is cost effective and easy to implement.

Keywords: solar PV module, PIC microcontroller, LDR sensor, ON/OFF smart solar charge controller, LED street lights, automatic brightness control etc.

I. Introduction

Major sources of conventional fossil fuels have exhausted to a large scale for its continuous use and these resources can no longer supply energy for 50-60 years from now[1]. To overcome this situation, solar energy can be used as alternative energy system which is operated in two different ways - solar photovoltaic system and solar thermal system[2]. The average increase of photovoltaic production is 48 percent per year since 2002[3] and the price of solar cells falls down to 20% for every doubling of industry volume[4].

To use photovoltaic energy at night, a battery is required for accumulating solar power. For the efficient use of the battery, a charge controller is needed to regulate the flow of current through solar panel to battery or through battery to load; which is an essential component of a power system, whether the source can be PV, wind, hydro, fuel or utility grid[5]. Due to the urbanization, the number of streets is increasing along with the street lights. For street lighting, about 10–38% of the total energy is required around the worldwide[6]. The LED lights can be used instead of traditional street lights to save 40-80% electricity than traditional lights[7]. Manually controlled street lights were susceptible to several errors and high power consuming[8} which can be impeded by a new method called optical control method[9] in which a light sensitive device, such as light dependent resistor(LDR)is used.

There have been a lot of studies done regarding smart charge controller and automatic brightness controlling of street lights. Sharath Patil G.S et al. (2015) designed a PV based automatic street light controlling system using sensors[1]. Automation of street lights was done by LDR sensors. Intensity of led street lights was controlled by IR sensor and pulse width modulation according to the vehicle movement. Wallies et al. (2014) developed a solar charge controller by using Microcontroller to protect the battery from deep discharging and over charging[10]. F.Sani et al. (2014) constructed a microcontroller based charge controller to charge 12V battery by using 80W solar panel[2]. Vikas Khare(2012) demonstrated a model of charge controller using microcontroller where the battery always charged at maximum power[3]. Mrs Jaya et al. (2012) presented a PIC based solar charging controller for battery to store solar energy and also mentioned how some disadvantages of analog circuits were solved by this controller[5]. A.Dawod et al. (2005) designed an intelligent battery charger based on a control technique which was implemented by fuzzy logic[11]. Rohaida Husin et al (2005) proposed an energy efficient microcontroller based automatic street lights (LED) controller using different types of sensors including laser sensor, light sensor and rain sensor[9]. Dr.D Asha et al. (2012) implemented a system for street lights to use solar power efficiently along with an automatic traffic

Auhtor α σ: Graduate Student, Department of Electrical and Electronic Engineering, University of Dhaka. e-mail: tahmidrupam33@gmail.com, e-mail: farhanatuli24@gmail.com
Author ρ: Professor, Department of Electrical and Electronic Engineering, University of Dhaka. e-mail: mhabib@du.ac.bd

© 2017 Global Journals Inc. (US)

control unit[6]. Riya et al. (2015) proposed an idea to control the brightness of LED street lights by detecting the number of vehicles automatically along with a traffic monitoring system[7].

In this paper, an idea is proposed for the effective use of solar energy for lighting up the street lights by using energy efficient LED street lights and ensuring the longevity of the battery by involving a charge controller. Solar power is stored in a lead-acid battery and an ON/OFF charge controller is implemented by microcontroller PIC16F876; where this controller reads the sets points of lead-acid battery and controls the battery to be charged fully without overcharging. Here ON/OFF charge controller is used instead of PWM charge controller because the charging is done by a solar panel. In case of a grid connection, PWM charge controller would be the first choice but for PV panel, it is not suitable as it produces 20% to 30 % of energy loss in case of a solar panel. In this proposed system, charge controller controls the connection between solar panel and battery. The LED light and battery connection is controlled with the help of microcontroller by sensing light intensity of surroundings. MiKroC software is used for the logic implementation of the proposed system.

II. Block Diagram of the System

As shown in the following block diagram, the complete system consists of mainly four blocks- Battery Voltage Sensing Circuit, Light Intensity Sensing Circuit, Switching Section and Brightness Control Section along with the microcontroller working as main controlling unit.

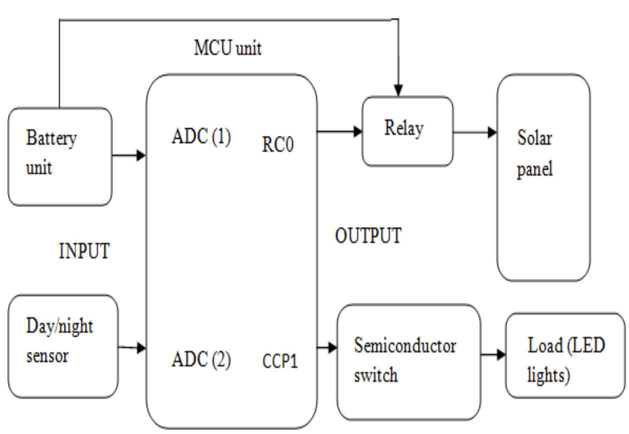


Fig. 1: Block diagram of the developed system

The design method of every section of the system is described in the following subheadings.

a) Voltage Sensing Circuit

A Lead acid battery is used in this system and it is required to sense the voltage of this battery which is fed to the microcontroller. To sense the battery voltage, a voltage divider circuit is used where resistors are chosen in a way that circuit can sense maximum battery voltage 15V. This voltage divider circuit is used to sense battery voltage because microcontrollers cannot take more than 5V as input.

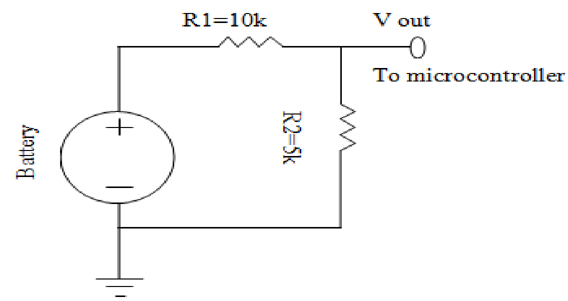


Fig. 2: Battery voltage sensing circuit

Here, a voltage regulator circuit is needed to generate constant 5V supply to operate the microcontroller. For this a 7805 IC is used to convert the battery voltage to 5V and its output is fed to the MCLR pin along with Vcc pin of the microcontroller to operate the microcontroller.

b) Light Intensity Sensing Circuit

To control the load (street light) automatically, light intensity of the environment needs to be sensed. A light dependent resistor (LDR) is used for this purpose. According to the variation of incident light, the resistance of the LDR changes.

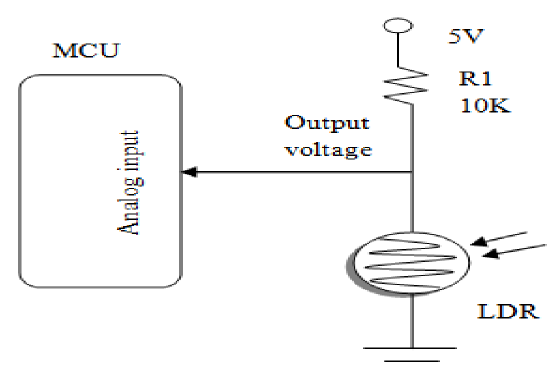


Fig. 3: Signal Conditioning Circuit

A voltage divider circuit is made using a fixed resistor (10k) and an LDR and the output of voltage regulator 7805 IC (5V) is used as voltage source. As the light of environment changes, resistance of LDR also changes and therefore the output voltage of circuit is varied. This voltage is sensed by the ADC unit of the microcontroller

c) Switching Section

After sensing the battery voltage the microcontroller generates an ON or OFF signal through one of its I/O pins based on a predefined algorithm to ensure the charging of the battery. When the voltage level of the battery is lower than the array reconnect voltage, 13.0V(4.33V sensed by the microcontroller) the

© 2017 Global Journals Inc. (US)

signal generated is ON (or logical 1). The pin is connected to a relay, an electro-mechanical switch to connect the battery with the solar panel. When ON signal is generated the relay turns on and connects the battery with the panel and eventually charging of the battery starts and continues till voltage regulation, 14.4V (4.8Vsensed by the microcontroller) is achieved. Moreover, if the battery voltage falls below 10.8V (3.6V for microcontroller) the load will be disconnected from the battery to prevent it from over discharging. When battery voltage rises to 11.5V (3.83V for microcontroller) then load is again connected to battery.

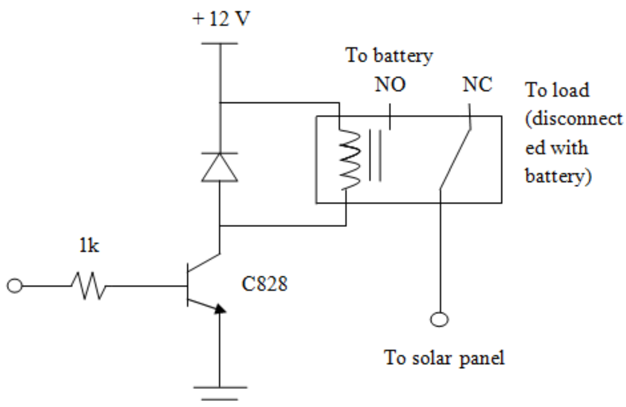


Fig. 4: Switching Section

d) Brightness Control Section

Pulse width modulation technique is used to control the loads (street light). Pulse Width Modulation, or PWM, is a technique for getting analog results by digital means. Digital control is used to create a square wave, a signal switched between on (5V) and off (0V). The duration of "on time" is called the pulse width. To get varying analog values, one can change or modulate that pulse width. To control the brightness of street light, an analog voltage is sensed by the microcontroller fed from the light intensity sensing circuit. If battery voltage is less than 10.8 volts, duty ratio will be 0% (0) i.e. the load is in OFF state. If the light intensity of environment is high enough (greater than 283.3 lux), then load also remains in OFF state. If light intensity of environment varies between 39.2 to 283.3 lux; PWM provides duty ratio of 50%. Below 39.2 lux, load will be lighten up in full brightness, PWM provides duty ratio of 100% (255), load is now in ON state. To drive street light (load), opto-coupler and power MOSFET are used as the output of microcontroller is not enough to lighten up the load.

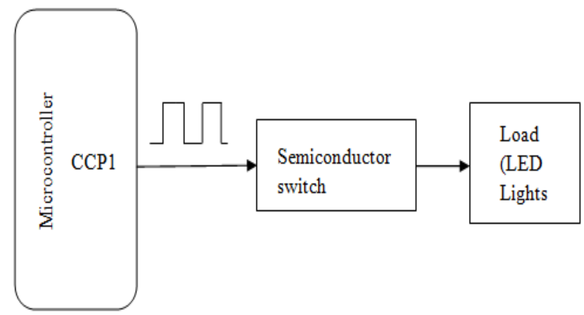


Fig. 5: Brightness Controlling Section

III. System Simulation

The whole system in simulated in proteus is shown in figure 6-

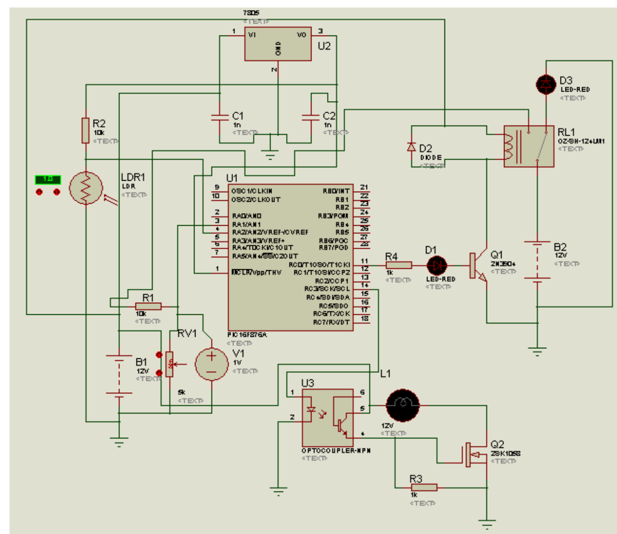


Fig. 6: Schematic diagram of the circuit

In this project, PORTA and PORTC of the microcontroller are used as input and output port respectively. Two pins of PORTA (RA1, RA2) are programmed as ADC module. These RA1 and RA2 pins are used to sense battery voltages and voltages from the light intensity circuit, respectively. In these two cases, voltage divider circuit is used as microcontroller cannot take more than 5 volts as input. The connection of the battery with the solar panel is controlled by relay which is connected to the output pin of microcontroller RC0 through transistor C828. Intensity of the street lights is controlled by pulse width modulation technique. Intensity of load will vary according to light intensity of environment. CCP module is activated for this purpose. The output of CCP1 is connected to optocoupler.

© 2017 Global Journals Inc. (US)

a) Required Calculations

Calculations for Battery Voltage Sensing:

Table.1: Battery Voltage Sensing:

Charge controller set points	Battery voltage (volts)	Voltage sensed by microcontroller (volts)	Equivalent decimal number
Voltage regulation (VR)	14.4	4.8	982
Array Reconnect Voltage (ARV)	13	4.33	887
Load Reconnect Voltage (LRV)	11.5	3.866	784
Low Voltage load Disconnect (LVD)	10.8	3.6	737

Calculations for LDR voltage sensing:

Table. 2: LDR voltage sensing

Light intensity	Resistance of the LDR(R2)(kΩ)	Voltage sensed by microcontroller(y)	Equivalent decimal number
Low	R2>=5.5	Vout>=1.77	>=363
Moderate	1<R2<5.5	0.4545<Vout<1.77	93-363
High	R2<=1	Vout<= 0.4545	<=93

b) Flow-chart of the System

The flowchart of the system is shown here-

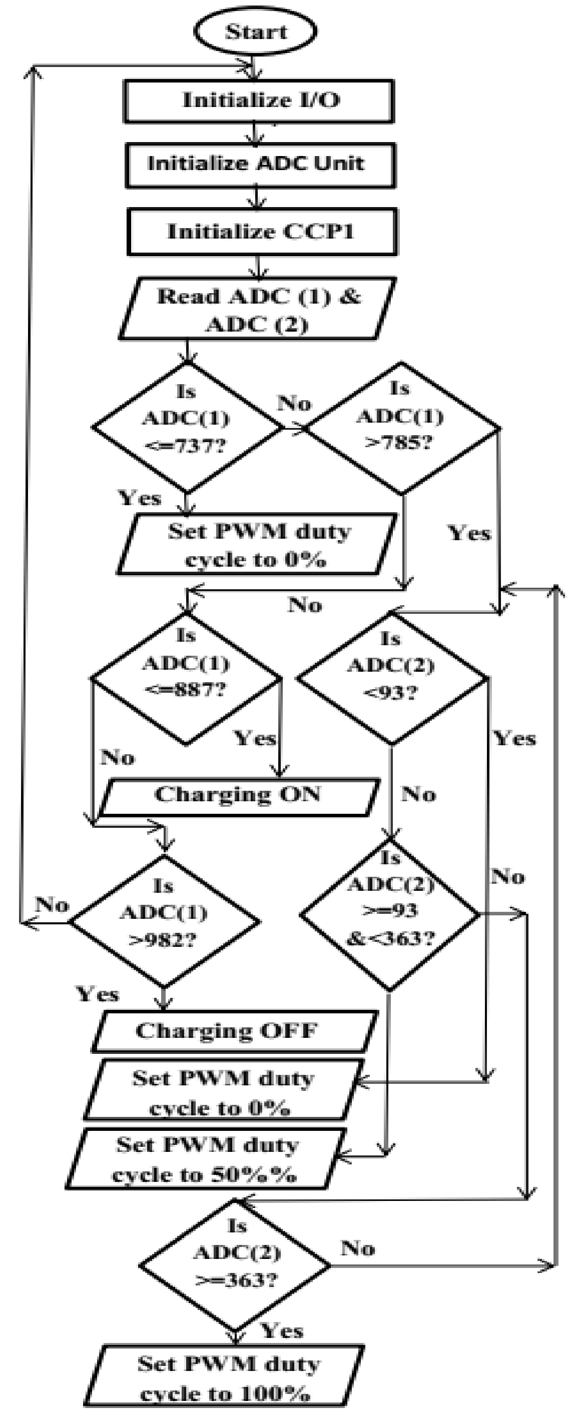


Fig. 7: Flow-chart of the system

IV. Hardware Design and Implementation

For hardware implementation the following components need to be connected according to the Fig. 6. The system was built on a bread board for testing. String of 12V LED lights has been used as street light. the complete hardware of the system is shown in Fig. 7.

© 2017 Global Journals Inc. (US)

Fig. 8: *Complete Hardware of the System*

a) Programming the Microcontroller

PIC microcontrollers can be programmed in several languages such as MPLab, C, Basic & FLOWCODE, which are most commonly used languages. But programming in lower level language, like assembly language, makes the process of programming more complicated. To avoid this problem, a high level language MikroC has been used. A program written in mikroC compiler includes Hex code, assembly code, header and other files. After writing a program code in C, the hex code is burned into microcontroller memory. For this a software is used named PICkit 2. After burning the hex file into the micro controller using a burner, the whole system was constructed on two bread boards. The solar panel and the battery were externally connected to the circuit.

V. Results and Discussion

A number of data were collected on different conditions after the hardware of the system was implemented. Among them some major cases are mentioned here-

A. Battery in charging state & load is ON with 100% duty ratio

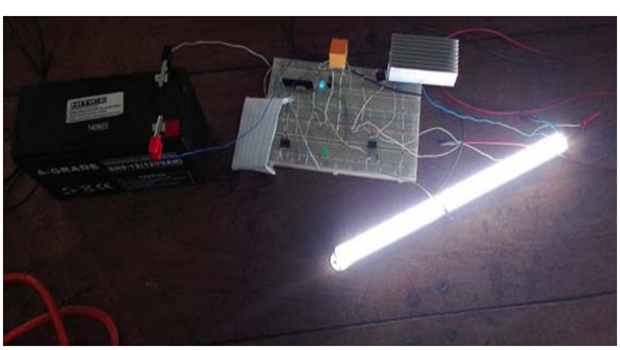


Fig. 9: (a)

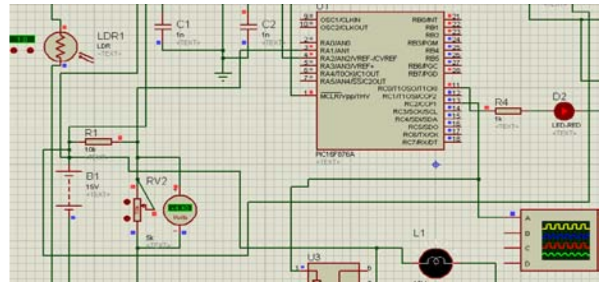


Fig. 9: (b)

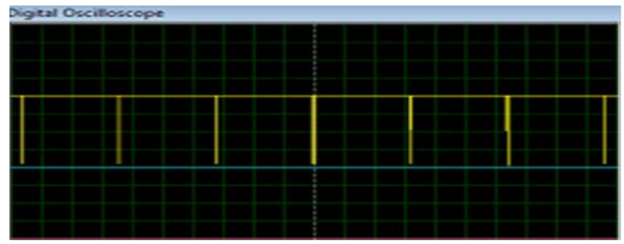


Fig. 9: (c)

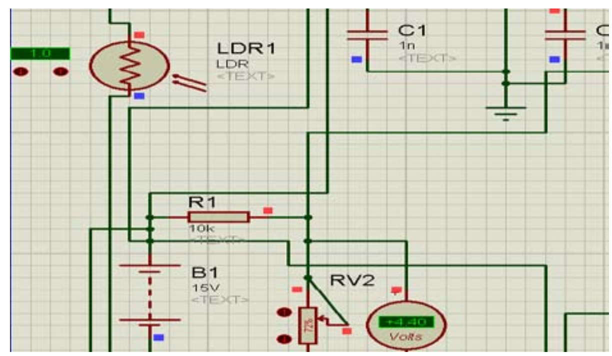


Fig. 9: (d)

In Fig.9.(a) a piece of paper was used to cover the LDR so that night condition could be simulated. As a result, the battery in charging state (blue LED ON) & load is ON with 100% duty ratio in hardware. And in Fig.9.(b) the same is shown in Simulation. Again in Fig.9.(c) and in Fig.9.(d) 100% duty ratio of PWM signal and the battery voltage(4.40V) and light intensity(1.0lx) reading in simulation is shown respectively.

B. Moderate light on LDR, battery is in charging state and PWM is set with 50% duty cycle

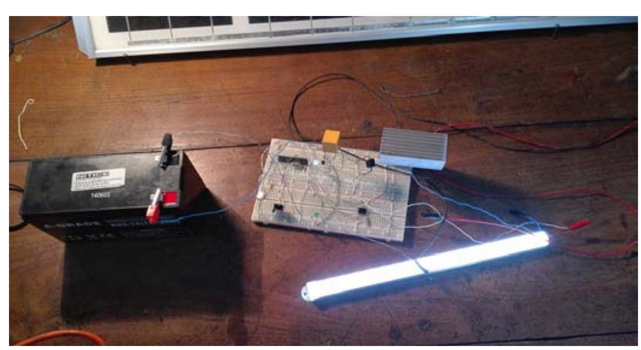


Fig.10: (a)

© 2017 Global Journals Inc. (US)

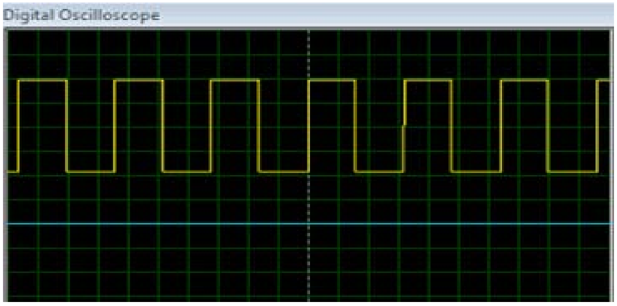


Fig. 1: (b)

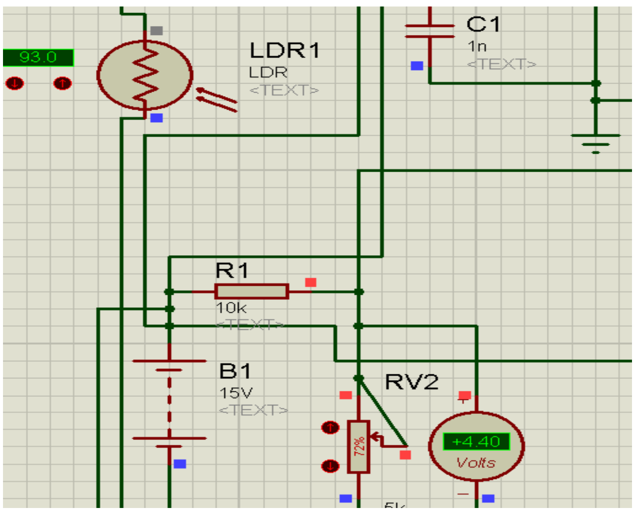


Fig.10: (c)

In this case Fig.10.(a) is showing that moderate light is incident on the LDR; battery is in charging state(blue LED) and PWM is set with 50% duty cycle in hardware. Fig10.(b) shows the 50% duty ratio of PWM signal and Fig10.(c) illustrates the battery voltage(4.4V) and light intensity reading(93.0lx) in simulation.

C. Battery in charging state and load in OFF state (0% duty ratio)

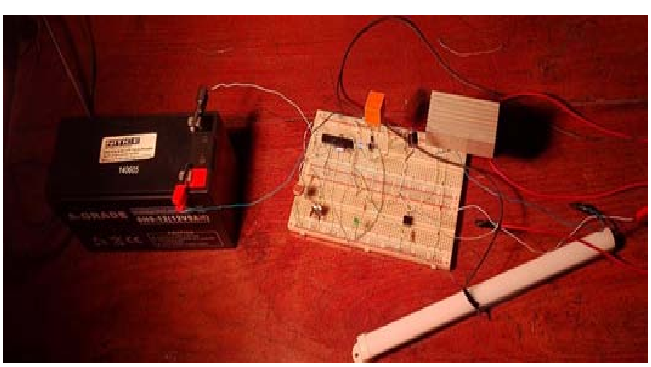


Fig. 11: (a)

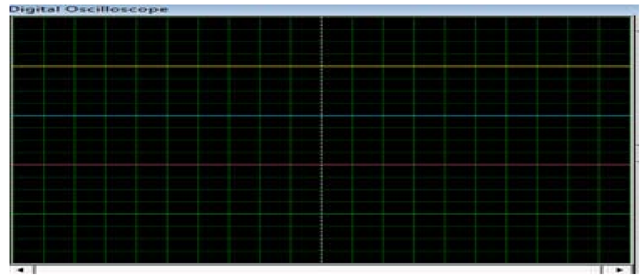


Fig.11: (b)

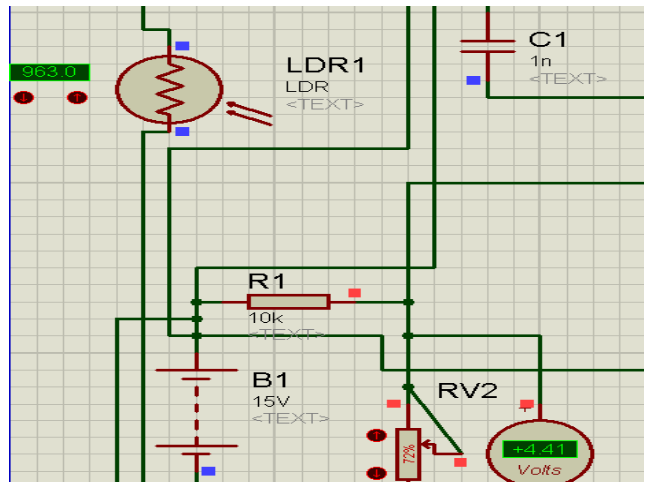


Fig. 11: (c)

In this particular case high artificial light was incident on the LDR. As a result Fig.11.(a) is showing that the battery is in charging state and the light is off. This is because the PWM signal is set with 0% duty cycle in hardware. This is shown in Fig.11. (b); 0% duty cycle of PWM. And in Fig.11.(c) the battery voltage(4.41V) and light intensity reading(963.0lx) in simulation circuit is shown.

D. Battery in discharging state and load in ON state

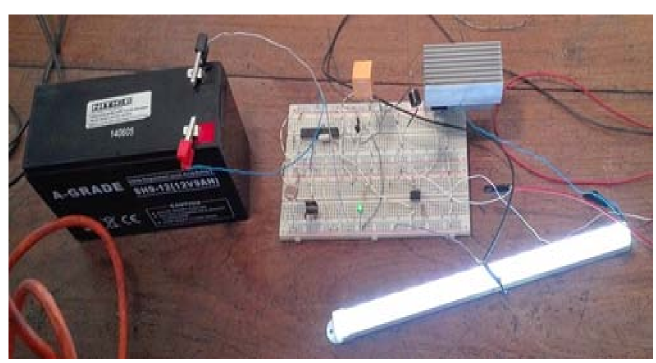


Fig.12: (a)

© 2017 Global Journals Inc. (US)

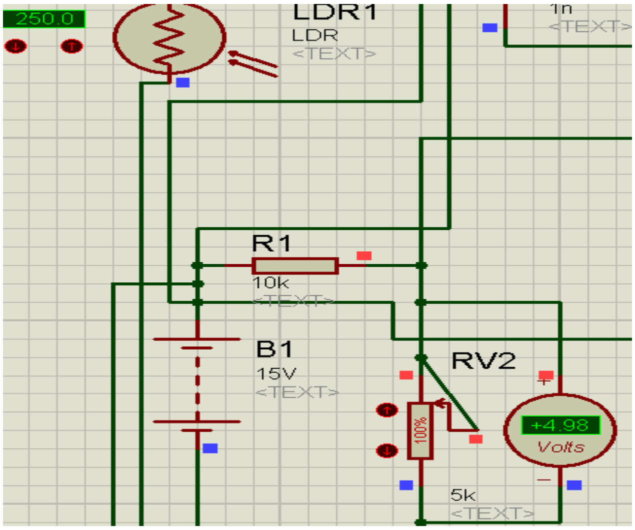


Fig. 12: (b)

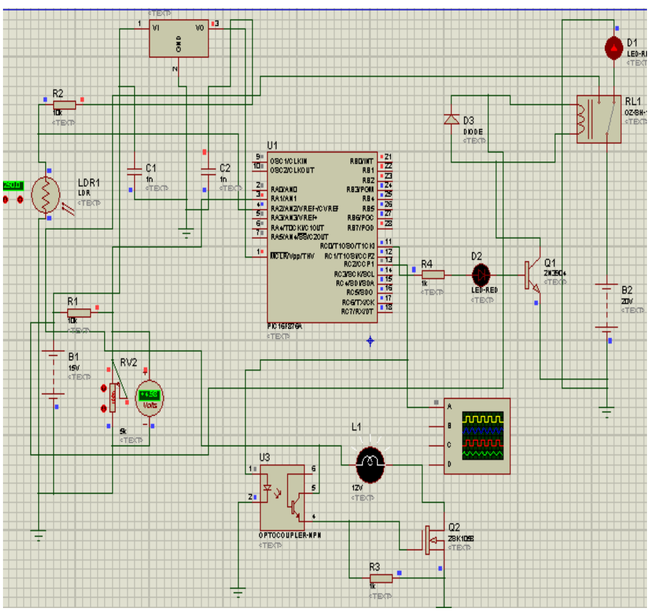


Fig.12: (c)

In this case Fig.12.(a) is showing that Moderate light in incident on the LDR and the battery is in discharging state(Green LED ON) and PWM is set with 50% duty cycle in hardware. In Fig.12.(b) Battery voltage(4.98V) and Light intensity reading(250.0lx) in simulation. And in Fig.12.(c) the whole system is shown in simulation for this particular case.

VI. Conclusion

In today's world the demand for energy is immense. To account for this ever growing need for energy, apart from the development of sustainable renewable energy sources, emphasis should also be given on redesigning systems to use energy more efficiently. In this paper a new model is presented which will reduce the power consumption of the street lighting system compared to conventional design. Here a saving of power is done with efficient use of the generated power i.e. with minimal wastage. Moreover, the charge controller can be used for electrification in the remote areas of Bangladesh using solar energy as it is cost effective. There are still scopes for future works. By proper selection of components based on their availability, the cost can be minimized. However, the only loss occurring in this circuit is due to the MOSFET (0.5 volts). Other than this the proposed system is both cost and energy efficient. In future, if this is implemented commercially, the overall cost can be reduced very significantly.

References Références Referencias

1. Sharath Patil G.S, Rudresh S.M, Kallendrachari.K3, M Kiran Kumar, Vani H.V, "Design and Implementation of Automatic Street Light Control Using Sensors and Solar Panel", ISSN : 2248-9622, Vol. 5, Issue 6, (Part - 1) June 2015, pp.97-100
2. Sani, H.NYahya, M. Momoh, I.G. Saidu and D.O. Akpootu, "Design and Construction of Microcontroller Based Charge Controller for Photovoltaic Application", e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 9, Issue 1 Ver. I (Jan. 2014), PP 92-97 www.iosrjournals.org
3. Mr.VikasKhare, "Microcontroller Based Solar Charge Controller for Power Application", International Journal of Electronics Communication and Computer Engineering Volume 3, Issue 1, ISSN 2249 –071X
4. https://en.wikipedia.org/wiki/Photovoltaics
5. Mrs Jaya N. Ingole, Mrs Dr. Madhuri A. Choudhary and Dr. R.D. Kanphade, "PIC BASED SOLAR CHARGING CONTROLLER FOR BATTERY", Mrs Jaya et al. / International Journal of Engineering Science and Technology (IJEST) ISSN : 0975-5462 Vol. 4 No.02 February 2012
6. Dr. D. Asha Devi, Ajay Kumar .Y.L, "Design and Implementation of CPLD based Solar Power Saving System for Street Lights and Automatic Traffic Controller", International Journal of Scientific and Research Publications, Volume 2, Issue 11, November 2012 1 ISSN 2250-3153
7. RiyaRanjan, MeghaGoyal, Bharat kumar, Sandeep Sharma, "Automatic Vehicle Detecting Street Light with Traffic Monitoring System", IJSRD|| National Conference on Inspired Learning|| Ocotrber 2015
8. MUSTAFA SAAD, ABDALHALIM FARIJ, AHAMED SALAH and ABDALROOF ABDALJALIL, "Automatic Street Light Control System Using Microcontroller", ISBN: 978-960-474-339-1
9. RohaidaHusin, Syed Abdul Mutalib Al Junid,ZulkifliAbdMajid, Zulkifli Othman, KhairulKhaiziMdShariff,HadzliHashim, "Automatic Street Lighting System for Energy Efficiency based on Low CostMicrocontroller" DOI

© 2017 Global Journals Inc. (US)

10.5013/IJSSST.a.13.01.05 ISSN: 1473-804x online, 1473-8031 print
10. Wallies Thounaojam1, V Ebenezer2, Avinash Balekundri, "Design and Development of Microcontroller Based Solar Charge Controller", www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 5, May 2014)
11. DAOUD and A. MIDOUN, "Fuzzy Control of a Lead Acid Battery Charger", JES 2005 on-line : journal.esrgroups.org/jes

© 2017 Global Journals Inc. (US)

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 17 Issue 2 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Modelling and Simulation of Microcode based Built-In Self Test Technology for Multiported Memory

By Prof. Dr. S. R Patil & Miss. Musle Dipali B.

Bharati vidyapeeths college of engg for women pune

Abstract- Now a day's embedded memory area and memory density is increasing. Due to this problem of fault is growing exponentially.It is necessary to detect and repair those faults. There are different methods to detect the faults present in memory. Asynchronous P-MBIST method is used to detect the faults. Simulation result includes asynchronous P-MBIST which detect mismatch of data occurred and it is shown by high fault pulse. To correct the detected fault redundancy circuit is used. This system is implemented using FPGA platform.

Keywords: built-in-self test (MBIST), built-in-self repair (BISR), asynchronous P-MBIST, microcode MBIST multiported memory, redundancy logic array, field programming gate array (FPGA).

GJRE-F Classification: FOR Code: 090699

MODELLINGANDSIMULATIONOFMICROCODEBASEDBUILTINSELFTESTTECHNOLOGYFORMULTIPORTEDMEMORY

Strictly as per the compliance and regulations of :

© 2017. Prof. Dr. S. R Patil & Miss. Musle Dipali B. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecom mons.org/ licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Modelling and Simulation of Microcode based Built-In Self Test Technology for Multiported Memory

Prof. Dr. S. R Patil [α] & Miss. Musle Dipali B. [σ]

Abstract- Now a day's embedded memory area and memory density is increasing. Due to this problem of fault is growing exponentionally.It is necessary to detect and repair those faults. There are different methods to detect the faults present in memory. Asynchronous P-MBIST method is used to detect the faults. Simulation result includes asynchronous P-MBIST which detect mismatch of data occurred and it is shown by high fault pulse. To correct the detected fault redundancy circuit is used. This system is implemented using FPGA platform.

Keywords: built-in-self test (MBIST), built-in-self repair (BISR), asynchronous P-MBIST, microcode MBIST multiported memory, redundancy logic array, field programming gate array (FPGA).

I. Introduction

According to the ITRS 2015,Now a days the memory area is increasing than logic area in SOCs.Fig.1[1] shows that shrinking the technologies give rise to defect and new fault models.Thus, the new trends in Multiported memory testing will be driven by the following items.

BIST: The new fault and new defects eliminate using BIST. The only solution that allows at-speed testing for embedded memories, it has generate fault detection and coverage, the higher repair efficiency only detecting the faults is no longer sufficient for SOCs so memory repair is also necessary for this purpose both diagnosis and repair algorithm are required.

BISR: Combining BIST with efficient and low cost repair schemes in order to improve the yield and system reliability as well.

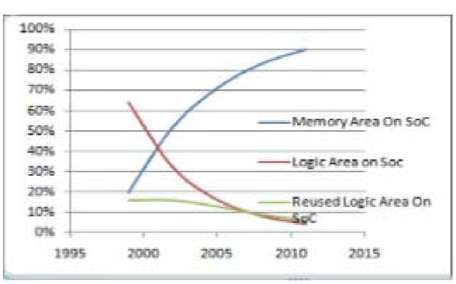


Fig.1: Embedded Memories in Future SOCs [1]

Auhtor α σ: Department of Electronics and telecommunication Bharati Vidyapeeth's College of Engineering for Women Pune, 43 Savitribai Phule Pune University. e-mails: srpatil44@gmail.com, dipali.musleb@gmail.com

There are two methods which are efficiently used. These methods are as follow:

1. *External Testing:* ATPG algorithm is used for external testing method ATPG algorithm consumes more area and to test vector generation is time consuming.
2. *Internal Testing:* BIST scheduling algorithm for internal testing it includes LFSR tuning, Test pattern generation. Whereas, BIST and Design for Test (DFT) is on same SOC and overcomes the limitation of the ATPG algorithm.

Microcode Asynchronous P-MBIST is implemented and compared with Synchronous P-MBIST. In Asynchronous M-BIST handshaking signals are used to communication between blocks of test controller. Whereas, in synchronous P-MBIST clocks are used to synchronize the test blocks on SOC. The BIST having two modes: Normal mode and scan mode The power consumption during test mode is more than the power consumption during normal mode. Hence to choose power efficient BIST method for multiported memory testing.

II. Related Work

Yash Jyothi et al.[1] introduced Asynchronous P-MBIST method for fault detection and repair of multiported memory. The main advantage is to get power efficient P-MBIST, it is being proposed to use handshaking signals instead of using clock and implemented on FPGA. Clocks are used to synchronize the test blocks on chip and handshaking signals are used to communicate between blocks of test controller.

Dr. R.K. Sharma et al.[2] introduced Redundancy Array Logic and BISR mechanism used to low cost repair the fault and to improve the system reliability.

Bo-Cheng Charles Lai et al.[4] introduced designs of multiported memories that leverage BRAMs have been proposed to attain better utilization of FPGA resources as well as system performance. BRAMs in an FPGA can support two access ports that can be used as either a read or a write port.

© 2017 Global Journals Inc. (US)

III. Built-in Self Test (BIST)

Memory Built-In Self Test is test circuitry used to test on-chip memory devices. It contains finite state machine to generate test vectors to test vectors to test memory during test mode. Test coller includes Address, Data, read/write control. This address, data and read/write control signal is given as input to comparator and multiplexer. Multiplexer uses two modes of operations: *Normal mode*-In normal mode memory acts as a normal memory. *Test Mode*-During test mode test coller provides data and address to memory for testing purpose. In test mode while performing read operation data from test coller and output of memory are given to comparator for fault detection. Then, comparator compares test vectors with memory output. If, memory is working properly then, No Fault is detected and it is declared as memory is fault free but, if fault pulse becomes high it shows that memory under test is faulty.

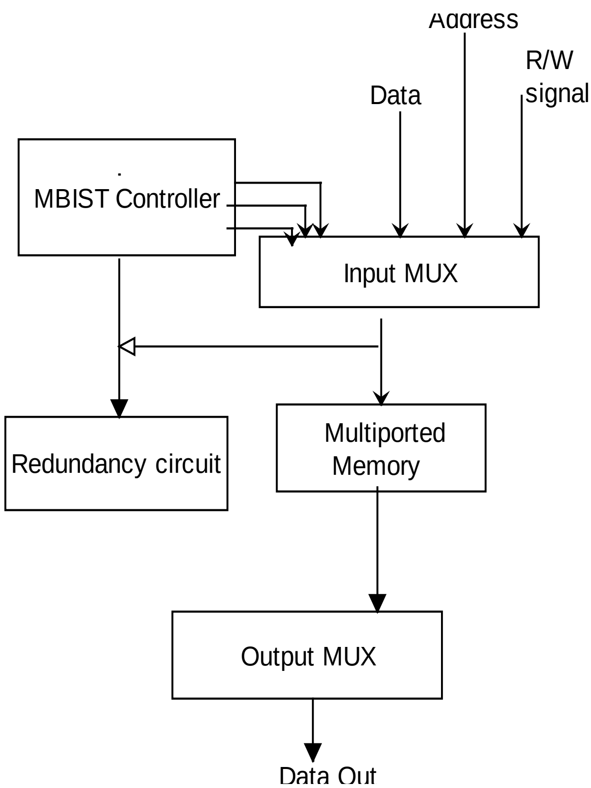


Fig. 2: Structure of P-MBIST

IV. Implementation of Asynchronous P-MBIST

The block diagram shown in Fig.3 [1] the asynchronous P-MBIST contains handshaking signals instead of using clock. Request and acknowledge signals perform communication in Asynchronous P-MBIST.

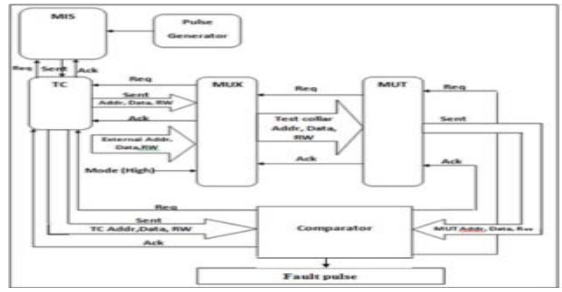


Fig. 3: Block Diagram of Asynchronous P-MBIST [1]

The control circuitry contain following blocks: Microcode Instruction storage unit, Test collar, comparator, Clock Generator. The Test Collar circuitry consists of Address Generator, RW Control and Data Control. Common Clock is used for Synchronous MBIST. In Microcode Instruction Storage (MIS), 4 instruction operations are stored that are R0, R1, W0, W1 as shown in Table I. [1]

Table No.1: Microcode Instruction [1]

Instruction	Description
R0	Read is low so no read operation occurs
R1	Read is high so read operation occurs
W0	Write is low so no write operation occurs
W1	Write is high so write operation occurs

V. Flowchart of Asynchronous P-MBIST

The flow of asynchronous P-MBIST is as shown in fig .4, fig. 5 and fig. 6. It follows the following steps:

i. If there is request from Microcode Instruction Storage (MIS) to Pulse generator (PG), then PG sends Start Pulse to MIS to start the asynchronous operation. In next step MIS checks for request from Test Collar (TC), if so it sends microcode instructions to TC. TC then sends the acknowledgement signal to pulse generator indicates that TC is getting instructions from MIs.

ii. Output of TC Data which includes test address, corresponding data and R/W control signals send to input multiplexer (MUX) if MUX sends high pulse of request. Multiplexer is originally not a multiplexer but concept used for this block is according to working of normal multiplexer. Here mode signal is select line for MUX.

iii. If mode=1then PMBIST works in test mode then it selects TC data. If mode=0 then it is in normal mode, during this mode test circuitry is in ideal condition and memory works as normal memory without under test and sends output of external Address, corresponding data and R/W control signal. When MUX is under test mode then it sends TC data to memory if request signal is high from memory to MUX.

© 2017 Global Journals Inc. (US)

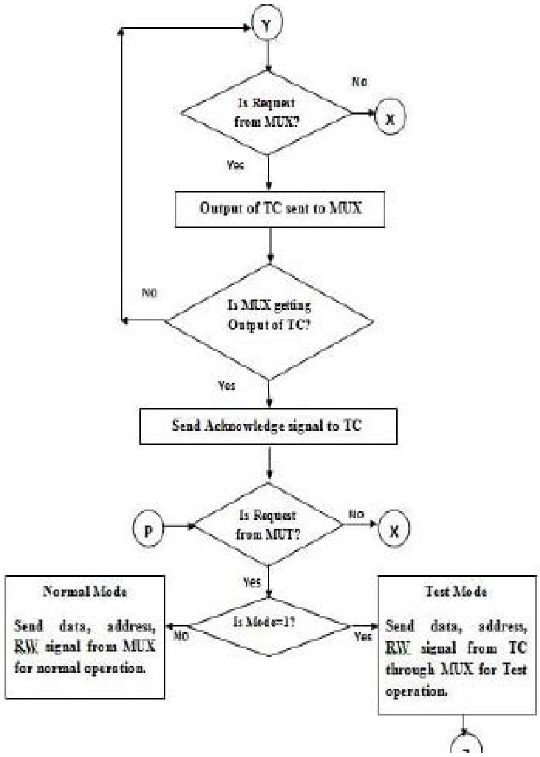


Fig. 4: Flowchart Step-I

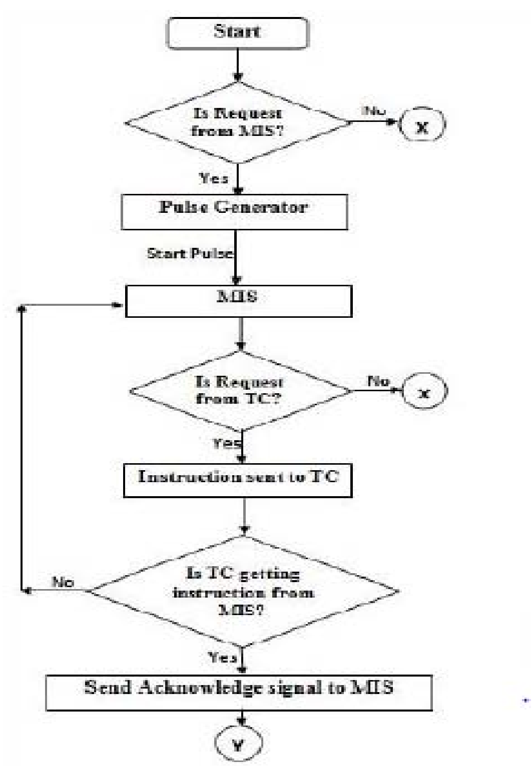


Fig. 5: Flowchart Step-II

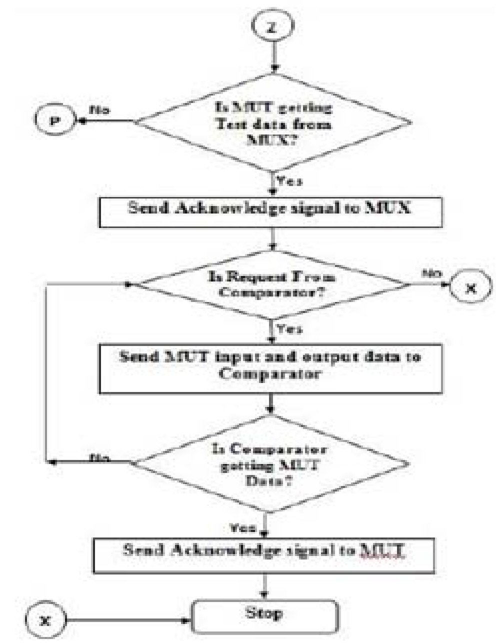


Fig. 6: Flowchart Step-III

VI. Comparator compares inputs provided by TC and memory output data during test mode and gives high fault pulse if any mismatch happens between these inputs

V. Asynchronous P-MBIST Simulation

The simulation of asynchronous P-MBIST is depending upon request signal and mode. Output Response: Normal Mode: When mode=0, MUX selects normal mode, then test controller is off so as comparator is off. At this moment memory acts as normal memory without under test and generates external address and data if rw=0(i.e. reads address and corresponding data).During this mode as comparator is off, no fault pulse is generated. In this mode, memoutdata (memory output) data is data (External data) provided for normal memory operation. Test Mode: If mode=1, Memory is under test. If req=1, microcode instruction storage generates Read/Write control for test collar. Test collar writes data if tcrw=0 otherwise read to memory through MUX. The data from test collar and output of memory is compared in comparator. If mismatch happens at output of comparator, comparator generates fault pulse=1 otherwise fault pulse=0[1].

VI. Repair Module

Fig.8.Shows the Repair Module including the redundancy array and output multiplexer and its interfacing with the existing BIST module.

Fig.7 An array of redundant words placed in parallel with the memory. The following interface signals are taken from the MBIST logic:1) A fault pulse indicating a faulty location address,2) Fault address,3)

Global Journal of Researches in Engineering (F) Volume XVII Issue II Version I Year 2017

© 2017 Global Journals Inc. (US)

Correct data that is compared with the results of Memory under test. The MBISR logic used here can function in two modes.

a) *Mode 1:* Test & Repair Mode

In this mode the input multiplexer connects test collar input for memory under test as generated by the BIST controller circuitry. As faulty memory locations are detected by the fault diagnosis module of BIST Controller, the redundancy array is programmed. A redundancy word is as shown in Figure. 7 The fault pulse acts as an activation signal for programming the array. The redundancy word is divided into three fields. The FA (fault asserted) indicates that a fault has been detected. The address field of a word contains the faulty address, whereas the data field is programmed to contain the correct data which is compared with the memory output. The IE and OE signals respectively act as control signals for writing into and reading from the data field of the redundant word.

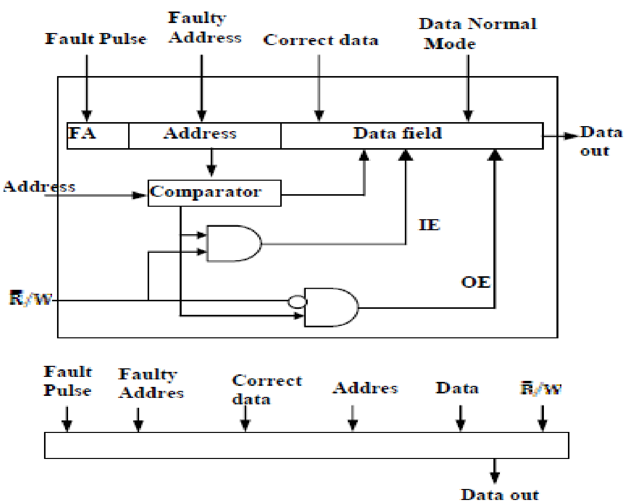


Fig. 7: Redundancy Word Line [2]

b) *Mode 2:* Normal Mode

During the normal mode each incoming address is compared with the address field of programmed redundant words. If there is a match, the data field of the redundant word is used along with the faulty memory location for reading and writing data. The output multiplexer of Redundant Array Logic then ensures that in case of a match, the redundant word data field is selected over the data read out (= 0) of the faulty location in case of a read signal. This can be easily understood by the redundancy word detail shown in Figure 7.

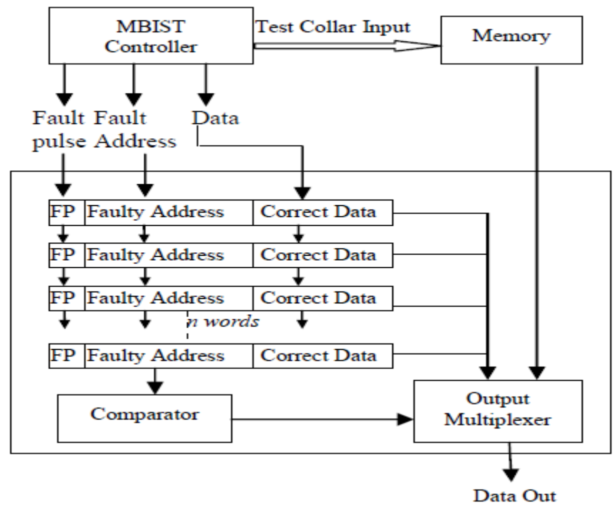


Fig. 8: Redundancy Array Logic [2]

Fig.8.Shows the simulated waveform of fault diagnosis module, magnified at seventh pulse to indicate how signals like 'fault pulse ', 'faulty location addresses and 'correct data' are generated by this module for successful interfacing with the Redundancy Array logic.[2]

VII. Results

1. Single port Memory

The single port memory support single read and write operation.

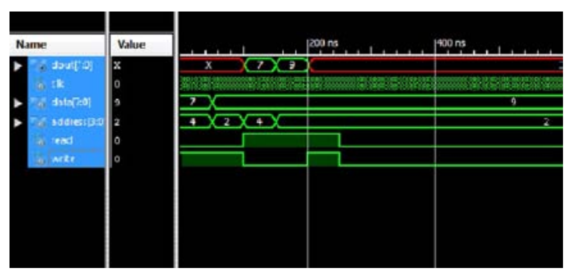


Fig.9: Result of Single port Memory

2. Dual port Memory

The single port memory support dual read and write operation.

Fig.10: Result of Dual port Memory

© 2017 Global Journals Inc. (US)

3. Multiported Memory

It requires significant amount of BRAMs to implement a memory module that supports multiple read and write ports.

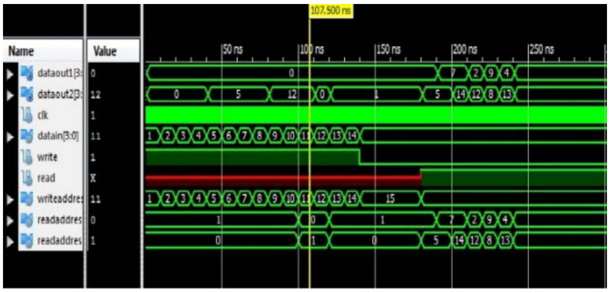


Fig. 11: Result of Multiported Memory

4. Synchronous P-MBIST

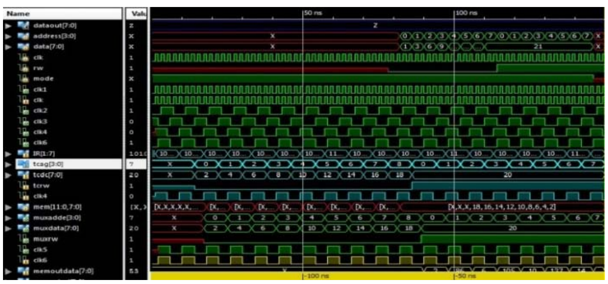


Fig.12: Simulation Result of Synchronous P-MBIST

5. Asynchronous P-MBIST

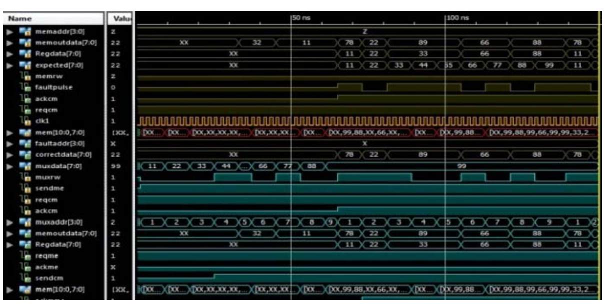


Fig.13: Simulation Result of Asynchronous P-MBIST

6. Redundancy Array Logic

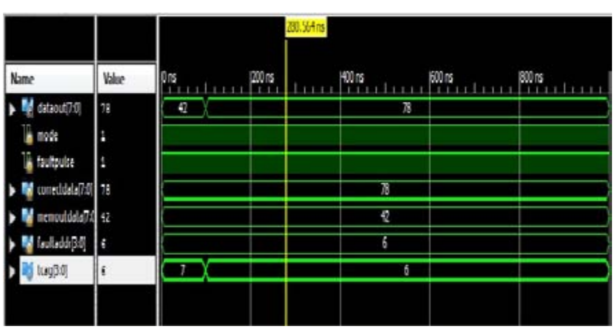


Fig.14: Simulation Result of Redundancy Logic Array

VIII. Conclusion

In simulation results of different types memories where implemented. The efficient BRAM-based multiported memory designs on FPGAs. The existing design methods require significant amounts of BRAMs to implement a memory module that supports multiple read and write ports. In simulation results of different methodology of P-MBIST where implemented. To synchronize the blocks synchronous PMBIST uses clock due to this it consume more power because of excessive switching activity and to communicate between the blocks of MBIST asynchronous MBIST uses handshaking signals and it consume less power. The word redundancy uses spare words in place of spare rows and columns. It stores faulty location address immediately supporting on-the-fly fault repair memory.

References Références Referencias

1. HassenMestiri, FatmaKahri BelgacemBouallegue, Mohsen Machhout, “A high speed AES design resistant to fault injection attacks”, Microprocessors and Microsystems journal,2016 Elsevier, pp.47-55
2. Dr. R.K. Sharma Aditi Sood, “Modeling and Simulation of Multi-Operation Microcode based Built-In Self Test for Memory Fault Detection and Repair”, IEEE Annual Symposium on VLSI, 2010
3. Prof.Vinod Kapse, Mohammed Arif, “Optimization of Microcode Built-In Self Test By Enhanced Faults Coverage for Embedded Memory”, IEEE Students’ Conference on Electrical, Electronics and Computer Science, 2012.
4. Bo-Cheng Charles Lai, Member, IEEE, and Jiun-Liang Lin,”Efficient Designs of Multiported Memory on FPGA”,ieee transactions on very large scale integration (vlsi) systems,2016.
5. G. A. Malazgirt, H. E. Yantir, A. Yurdakul, and S. Niar,“Application specific multi-port memorycustomization in FPGAs,” in Proc. IEEE Int.Conf. Field Program. Logic Appl. (FPL), Sep. 2014, pp. 1–4.
6. Sandra Irobi Zaid Al-Ars Said Hamdioui.Memory Test Optimizationfor Parasitic Bit LineCoupling in SRAMs. IEEE International Test Conference, 2010.
7. N. Z. Haron, S.A.M. Junos, A.S.A. Aziz, “Modelling and Simulation of Microcode Built-In Self test Architecture for Embedded Memories”, In Proc. of IEEE International Symposium on Communications and Information Technologies pp. 136-139, 2007.
8. S. Hamdioui, G.N. Gaydadjiev, A.J .van de Goor, “State-of-art and Future Trends in Testing Embedded Memories”, International Workshop on Memory Technology, Design and Testing (MTDT’04),2004.
9. P. Bernardi, M. Grosso, M. S. Reorda, and Y. Zhang, "A programmable BIST for DRAM testing

© 2017 Global Journals Inc. (US)

and diagnosis," in Test Conference (ITC), 2010 IEEE International, 2010, pp. 1-10.
10. C. E. LaForest and J. G. Steffan, "Efficient multi-ported memories for FPGAs,"inProc. 18th Annu. ACM/SIGDA Int. Symp. Field Program.Gate Arrays, 2010, pp. 41–50.
11. Xilinx. 7 Series FPGAs Configurable Logic Block User Guide,accessed on May 30, 2016. [Online].Available:http://www.xilinx.com/support/documentation/user_guides/ug474_7Series_CLB.pdf.
12. C. E. LaForest, M. G. Liu, E. Rapati, and J. G. Steffan, "Multi-ported memories for FPGAs via XOR," in Proc. 20th Annu. ACM/SIGDA Int. Symp. Field Program. Gate Arrays (FPGA), 2012, pp. 209–218.

© 2017 Global Journals Inc. (US)

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 17 Issue 2 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Modeling and Mitigation on Conducted Emission for Switch Mode Power Supply

Li Lin, Qiu Dongmei , Yan Wei & Gao Xiang
Nanjing Normal University

Abstract- The switch mode power supply (SMPS) have been widely used in the electrical and electronics systems for AC-DC and DC-DC power conversion, which can generate a lot of electromagnetic interference (EMI), especially conducted emission (CE) from 9kHz to 30MHz. The traditional CE models and mechanisms have been present for three line systems, including live, neutral and ground lines, while a novel CE models and mechanisms have been proposed in the paper for two line SMPS. And the voltage division factor, isolation factor and impedance under SMPS side of artificial mains network have been studied based on high frequency parasitic parameters to analyze the CE measurement uncertainty. Moreover, three methods have been designed to reduce the CE of SMPS, such as the capacitor shunt between the source and drain electrodes of MOSFET, CM choke and crosstalk choke, and the capacitors matrix.

Keywords: *electromagnetic interference (EMI); noise mechanism; noise mitigation; SMPS; conducted emission.*

GJRE-F Classification: *FOR Code: 290901*

MODELINGANDMITIGATIONONCONDUCTEDEMISSIONFORSWITCHMODEPOWERSUPPLY

Strictly as per the compliance and regulations of :

© 2017. Li Lin, Qiu Dongmei , Yan Wei & Gao Xiang. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecom mons.org/ licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Modeling and Mitigation on Conducted Emission for Switch Mode Power Supply

Li Lin α, Qiu Dongmei α, Yan Wei σ & Gao Xiang ρ

Abstract- The switch mode power supply (SMPS) have been widely used in the electrical and electronics systems for AC-DC and DC-DC power conversion, which can generate a lot of electromagnetic interference (EMI), especially conducted emission (CE) from 9kHz to 30MHz. The traditional CE models and mechanisms have been present for three line systems, including live, neutral and ground lines, while a novel CE models and mechanisms have been proposed in the paper for two line SMPS. And the voltage division factor, isolation factor and impedance under SMPS side of artificial mains network have been studied based on high frequency parasitic parameters to analyze the CE measurement uncertainty. Moreover, three methods have been designed to reduce the CE of SMPS, such as the capacitor shunt between the source and drain electrodes of MOSFET, CM choke and crosstalk choke, and the capacitors matrix. The experiment results show that the CE of the power concentrator and colonoscopy can be suppressed well and pass EN 55022 class B, thus realize the proposed approaches good validation.

Keywords: electromagnetic interference (EMI); noise mechanism; noise mitigation; SMPS; conducted emission.

I. Introduction

Switch mode power supply (SMPS) has been widely applied in the electrical and electronics devices, which can realize the AC-DC, DC-DC conversion and generate larger amount of electromagnetic interference (EMI), especially conducted emission (CE) from 9kHz and 30MHz [1-5]. The CE standards have been established by the most countries and areas, such as EN 55022 [6].

In recent years, the CE models and mechanisms for live, neutral and ground lines system have been proposed to analyze the noises paths, which contributes to noise suppression [7-11]. The CE models consist of common mode (CM) and differential mode (DM) noises. The CM noise path is from live/neutral line to ground line, and the DM path is from live line to neutral line. Four kinds of noise separation networks have been proposed to determine the CE mechanism by extracting CM and DM noises by Paul, See, Mardiguian and Guo [2, 12-14]. Paul network is composed of two radio frequency transformers with 1:1 and artificial switch, through which the high frequency (HF) noises are generated and coupled [2]. The core of See network is also two radio frequency transformers with 2:1, but the HF noises are generated through the parasitic capacitor between the primary and secondary coils [12]. To improve the topology of network, the network was designed with one radio frequency transformer with 2:1 by Mardiguian [13]. Moreover, the 0° and 180° power dividers have been used to constitute the noise separation network [14].

Based on the above models and mechanism, a lot of categories have been carried out to reduce the CE noises [15-19]. The EMI noises from DC-DC Buck conversion has been suppressed by employed MOSFET, decoupling capacitors and optimal design for PCB [15]. A frequency modulated (FM) source of conducted emission has an adverse effect on a DC power system and spread spectrum modulation is proposed to reduce EMI noises [16]. The Power Integrity problem for high speed systems is discussed in context of selection and placement of decoupling capacitors. The optimal capacitors and their locations on the board are found using the presented methodology, which can be used for similar power delivery networks in high speed systems [17]. A modified LLCL-filter topology is proposed to provide enough attenuation on the conducted EMI noise as well as to reduce the DC side leakage current [18]. A new method to reduce CM EMI at the DC input of variable-speed motor drives is analyzed. Unlike conventional passive or active filtering techniques that rely on impedance mismatch or active noise cancellation, the method uses a passive circuit with matched impedance to cancel the inverter CM current [19]. However, the above noise reduction methods can't obtain the EMI source and solve the EMI problem fundamentally in the economy and practical scale.

In view of above analysis and on basis of the acquired achievements about EMC of electronic equipments, the CE models and mechanisms for SMPS have been analyzed in the paper. And the CE measurement uncertainty was studies based on the voltage division factor, isolation factor and impedance under SMPS side of artificial mains network. Then, three methods have been proposed to reduce the CE, such as the capacitor shunt between the source and drain electrodes of MOSFET, CM choke and crosstalk choke, and the capacitors matrix. The experiment results show that the CE noises of the power concentrator and colonoscopy can be suppressed effectively and efficiently by using the present approaches, while can pass the EN 55022 and improve the safety and EMI performance.

Auhtor α: Jiangsu Institute of Metrology, Nanjing, 210023, China.
Auhtor σ: School of Electrical and Automation Engineering, Nanjing Normal University, Nanjing 210042, China. e-mail: 61197@njnu.edu.cn
Corresponding Author ρ: 61188@njnu.edu.cn.

© 2017 Global Journals Inc. (US)

II. SMPS Operation Description

SMPS can support direct current (DC) power to the load through four diodes and metal oxide semiconductor field effect transistor (MOSFET). Voltage dependent resistance (VDR) was employed to resist and suppress the external surges and interferences. Three capacitors and common mode (CM) choke were used to reduce the high frequency (HF) EMI noises. However, a large amount of EMI noises were generated by SMPS via four diodes and FET, which will go to power supply through power line and influence other electrical and electronics devices.

CM and differential mode (DM) models were established to analyze the noise mechanism and suppress the above EMI noises based on three line system including live, neutral and ground lines, as shown in Fig.1.

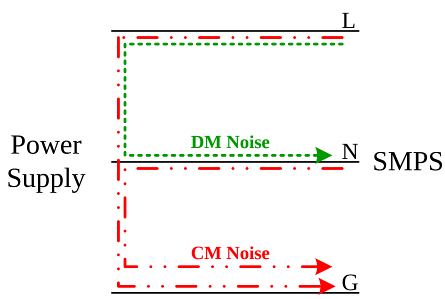


Fig. 1: CM and DM noise mechanism based on three line system

Due to the difference between the topology of SMPS (two line system without ground line) and traditional three line system, the conducted emission mechanism will be studied.

III. Uncertainty of Conducted Emission Measurement

According to EN 55022 and FCC Part 15, conducted emission can be detected by EMI receiver and artificial mains network (AMN), where quasi peak detector and average detector should be fixed on the EMI receiver.

To analyze the uncertainty of CE measurement, the topology structure and HF parasitic parameters of AMN will be investigated. According to CISPR 16, the topology structure is shown in Fig.2, where C_1 is 1μF, C_2 is 0.1μF, R_1 is 50Ω, R_2 is 1kΩ and L_1 is 50μH. The HF noise from 9kHz to 30MHz in power supply can be reduced by capacitor C_1 and inductance L_1, and the 50Hz current is also ordinary and functional. The CE from 9kHz to 30MHz in SMPS can be extracted through capacitor C_2. Resistance R_1 is used to bypass flow and resistance R_2 is designed to measure CE.

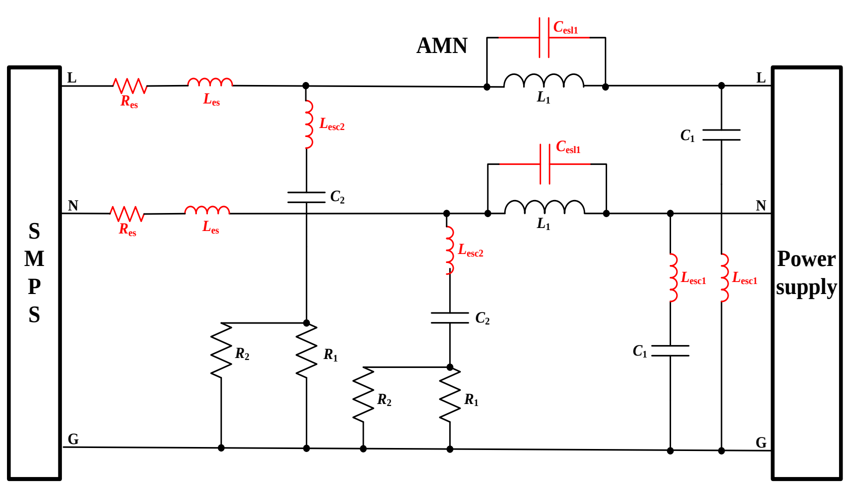


Fig. 2: Topology structure of AMN based on CISPR 16 (red characters are HF parasitic parameters)

Considering the HF parasitic parameters of the above capacitors, inductances and resistances, as shown in Fig.2, L_{esc1} and L_{esc2} are the parasitic inductance of C_1 and C_2, respectively. C_{esl1} is the parasitic capacitor of L_1. L_{es} and R_{es} are the parasitic inductance and resistance of the interface adapter. In the paper, R_{es} is neglected due to the adapter design and manufacturing technique.

To analyze the characteristic of AMN, the voltage division factor, isolation factor and impedance under SMPS side were defined as

$$\begin{aligned} VIF_L &= 20\log\left|\frac{U_L}{U_{LG}}\right| \quad VIF_N = 20\log\left|\frac{U_N}{U_{NG}}\right| \\ IRR_L &= 20\log\left|\frac{U_L}{U_{PLG}}\right| \quad IRR_N = 20\log\left|\frac{U_N}{U_{PNG}}\right| \end{aligned} \tag{1}$$

© 2017 Global Journals Inc. (US)

Where, VIF_L and VIF_N denote the live and neutral lines voltage division factor of AMN, IRR_L and IRR_N represent the live and neutral lines isolation factor of AMN, U_L and U_N express the total CE of live and neutral lines, U_{LG} and U_{NG} express the HF EMI noise between live/ neutral and ground lines.

a) The voltage division factor of AMN

To analyze the voltage division factor of AMN, the above parasitic parameters were considered lonely as shown in Tab.1 and the results were shown in Fig.3.

Table.1: Four Parasitic Parameters Assumption

L_{esc1}	1 nH
L_{esc2}	0.1 nH
C_{esl1}	40 pF
L_{es}	100 nH

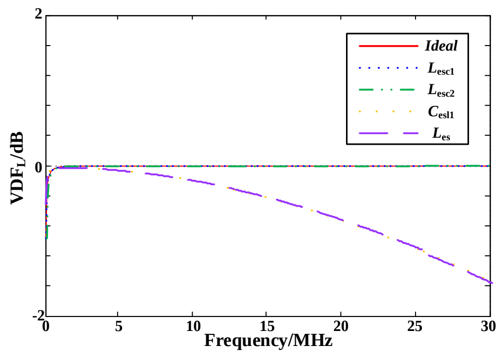


Fig. 3: The voltage division factor of AMN considering HF parasitic parameters

As shown in Fig.3, L_{esc2} and L_{es} have great influence on the voltage division factor of AMN.

b) The isolation factor of AMN

To analyze the isolation factor of AMN, the above parasitic parameters were considered lonely as shown in Tab.I and the results were shown in Fig.4, where the L_{es} can be neglected due to the measurement circuit.

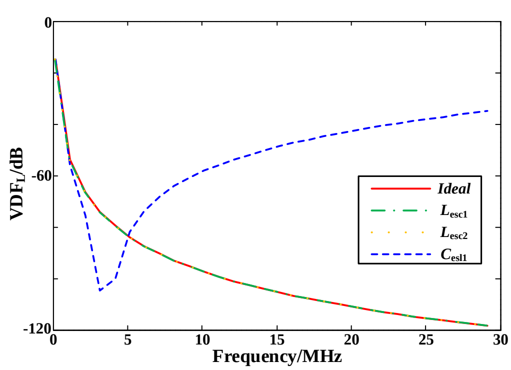


Fig.4: The isolation factor of AMN considering HF parasitic parameters

As shown in Fig.4, C_{esl1} have great influence on the isolation factor of AMN.

c) The impedance under SMPS side of AMN

To determine the impedance under SMPS side of AMN, L_{es} was considered as 10nH and 100nH, respectively, and the other parasitic parameters can be neglected due to the measurement circuit, as shown inFig.5.

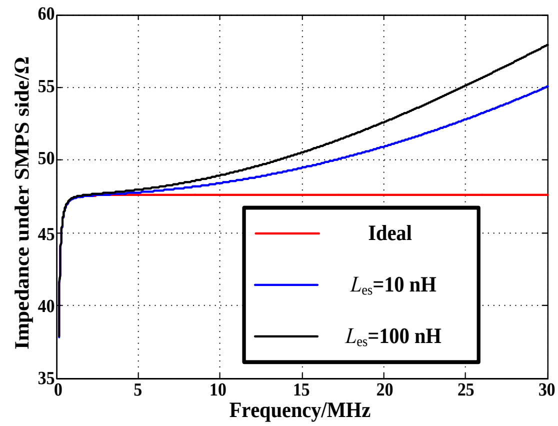


Fig.5: The impedance under SMPS side of AMN considering HF parasitic parameters

As shown in Fig.5, with the L_{es} and measurement frequency increasing, the impedance under SMPS side was increasing greatly.

Therefore, the proper AMN should be designed and employed to determine the CE and decrease the uncertainty of CE measurement through capacitor and inductance matching.

IV. CE Characteristic Mechanism Model

a) CM and DM models

Due to the difference between the two line SMPS system and three line system, the CE characteristic mechanism model should be established. Considered that SMPS have live and neutral lines but no ground line, the CM and DM noise transmission loop can't be formed and realized.

As shown in Fig.2, the two different results can be obtained based on EN 55022, as follows:

$$I_L = I_N \quad I_L \neq I_N$$

Where, I_L and I_N denote the total CE current through live and neutral lines. Based on the formula (2), the unbalanced noise current can be defined as

$$I_L - I_{DM} = I_N + I_{DM} \tag{3}$$

Where, I_{DM} represents the unbalanced noise current and can be considered as DM noise current. Then,

$$\begin{cases} I_{CM} = I_L - I_{DM} \\ I_{CM} = I_N + I_{DM} \end{cases} \tag{4}$$

Where, I_{CM} signifies the balanced noise current and can be considered as CM noise current.

© 2017 Global Journals Inc. (US)

Based on Fig.2, the total live line noise have two bypass loops, such as live to ground noise I_{LG} and live to neutral noise I_{LN}. Similarly, the total neutral line noise also have two bypass loops, such as neutral to ground noise I_{NG} and neutral to live noise I_{NL}. Supposed that

$$\begin{aligned} I_L &= I_{LG} + I_{LN} \\ I_N &= I_{NG} + I_{NL} \end{aligned} \tag{5}$$

Moreover, the amplitude of the I_{LN} and I_{NL} were equal but the phases were opposite.

$$I_{NL} = -I_{LN} \tag{6}$$

By substituted to formula (5), it can be obtained

$$I_L = I_{LG} + I_{LN} \quad I_N = I_{NG} - I_{LN} \tag{7}$$

and,

$$I_{LG} = I_L - I_{LN} \quad I_{NG} = I_N + I_{LN} \tag{8}$$

Considered I_{LN} as I_{DM},

$$\begin{cases} I_{CM} = I_L - I_{DM} = I_L - I_{LN} = I_{LG} \\ I_{CM} = I_N + I_{DM} = I_N + I_{LN} = I_{NG} \end{cases} \tag{9}$$

Based on the formula (3) and (9), the CM noise can be defined as

$$U_{CM} = U_{LG} = U_{NG} \quad U_{CM} = \frac{U_L + U_N}{2} \tag{10}$$

The equivalent transmission circuit of CM noise was shown in Fig.6(a).

Where, U_{CM} and Z_{CM} represent the equivalent CM noise source and its impedance.

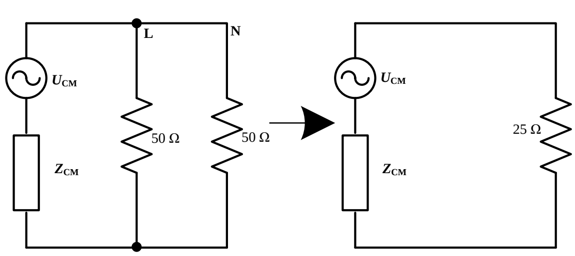
Based on the formula (3) and (8), the DM noise can be defined as

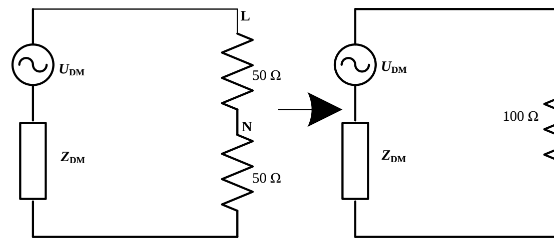
$$I_{DM} = \frac{I_L - I_N}{2} \quad U_{DM} = \frac{U_L - U_N}{2} \tag{11}$$

The equivalent transmission circuit of DM noise was shown in Fig.6(b).

Where, U_{DM} and Z_{DM} represent the equivalent DM noise source and its impedance.

Moreover, Z_{CM} and Z_{DM} can be determined by employing the insertion method, dual current probe method, single current probe current, scattering parameter method and the proposed dual resistance calibration method.





(a). *CM noises* (b). *DM noises*

Fig. 6: Noise equivalent transmission circuits

b) CE model for SMPS

Due to the two lines system, the parasitic capacitor to ground can be considered to analyze the equivalent bypass circuits of CM and DM noises, as shown in Fig.7.

The DM noise path was from live line to neutral line, the same as the three line system, as shown in Fig.1. However, the CM noise path was from live/neutral line to ground line, then to the SMPS through the parasitic capacitor C_{PG}.

Therefore, CE for SMPS still have CM and DM noises, but not the only DM noise, where noise suppression categories should be designed not only for DM noise but also for CM noise.

Moreover, the DM noise is much larger than CM noise in general because the parasitic capacitor is little, even ignored.

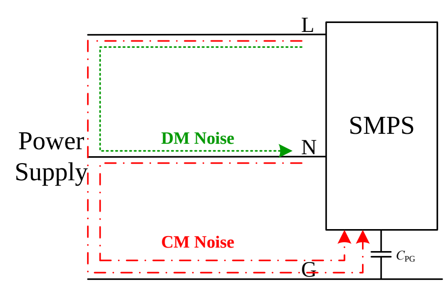


Fig. 7: CE model for SMPS

V. CE Mitigation Method for SMPS

a) The capacitor shunt between the source and drain electrodes of MOSFET

The switch frequency can be controlled through the grid electrode of MOSFET and the HF noise will generate and couple to the source and drain electrodes due to the MOSFET. The frequency of noises are based on the switch velocity, basically from 9kHz to 30MHz, which is the CE source.

The capacitor shunt between the source and drain electrodes can be used to reduce the above HF noises. Moreover, the value of the capacitor should be smaller than 0.1μF not only for the noise mitigation but also for the safety regulations & design, as shown in Fig.8, where, C_4 denotes the capacitor shunt between the source and drain electrodes of MOSFET.

© 2017 Global Journals Inc. (US)

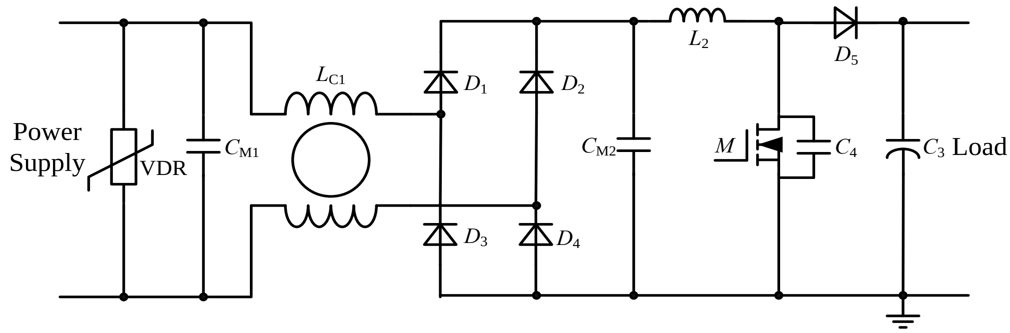
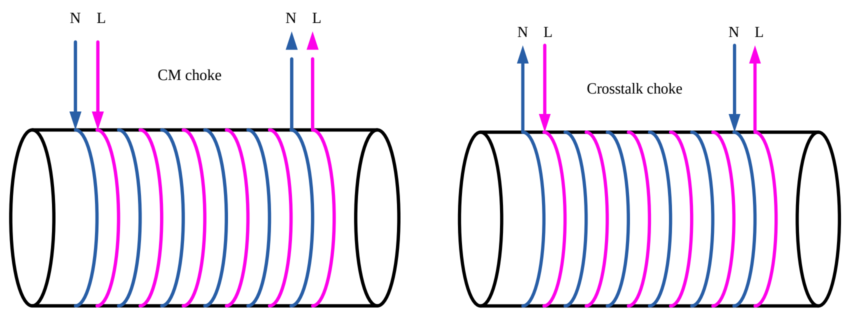


Fig. 8: Topology structure of SMPS

b) *CM choke and crosstalk choke*

The CM choke can be employed to suppress the CM noises, but can't solve the environmental electromagnetic field coupling. As shown in Fig.9(a), the live and neutral lines are in the same direction in the CM choke, which can well reduce the CM noise due to the electromagnetic field offset. Meanwhile, the CM choke can be considered as two electric dipoles which can receive the environmental electromagnetic field greatly and couple to the power lines. And the amplitude of the coupling noise is based on the length of dipoles and the noise frequency.

The crosstalk choke whose live and neutral lines are in the different orientation, can be used to solve the above problem. With different of CM choke, the crosstalk choke can be considered as the magnetic dipole, which can also obtain the environmental electromagnetic field. And the magnitude of the coupling noise resolves the area of dipole and the noise frequency. As shown in Fig.9(b), the area of the dipole is the area between the live and neutral lines, which is very little. As shown in Fig.12, the L_{C1} represents the CM choke and crosstalk choke.



(a). *CM choke* (b). *Crosstalk choke*

Fig. 9: CM choke and crosstalk choke

c) *The capacitors matrix*

The single capacitor with the fixed value can suppress the certain spectrum noise due to HF parasitic parameter of the capacitor, such as the parasitic inductance of the pins. The capacitors matrix can be employed to solve the problem, which consists of 100pF, 1nF, 10nF, 0.01μF and 0.1μF. The different frequency noise will be reduced by the capacitors with different values, as shown in Tab.2. As shown in Fig.8, the C_{M1} and C_{M2} denote the two capacitors matrix.

Tab. 2: Noise Mitigation Based on Different Capacitors

Capacitor's Value	Reduced noises frequency
100pF	20MHz and the above
1nF	10MHz-30MHz
10nF	5MHz-20MHz
0.01μF	500kHz-10MHz
0.1μF	9kHz-1MHz

VI. EXPERIMENT VERIFICATION

To verify the proposed methods, the SMPSs of the power concentrator and colonoscopy are studied in the paper. In the experiment, R&S EMI receiver ESL3 and R&S artificial mains network (AMN) ENV216 are used to determine the CE generated by the above devices.

a) *SMPS of the power concentrator*

The original CE result of the power concentrator is shown in Fig.10(a),(b). According to EN 55022 Class B, the noise can't pass the standard from 150kHz to 10MHz. The average noises are 54dBμV@13.56MHz and 55dBμV@27.12MHz. And it exceeds 20dBμV from 3MHz to 5MHz, even critical.

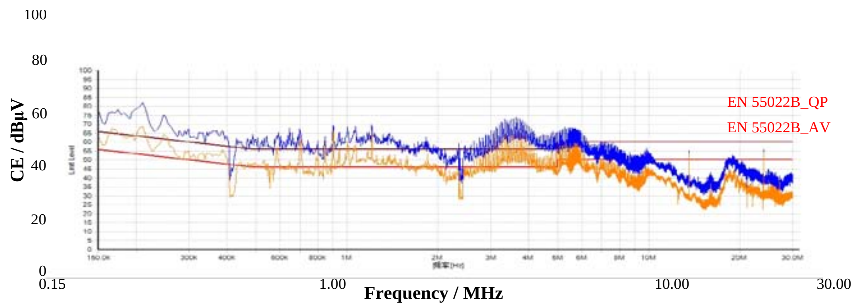
Based on the proposed method, the mitigation approaches are designed as follows:

© 2017 Global Journals Inc. (US)

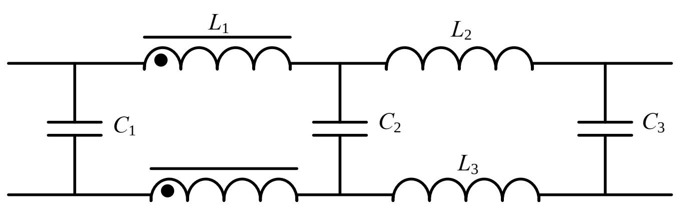
1. EMI filter for SMPS of the power concentrator is designed, as shown in Fig.10(c), where L_1 denotes 10mH CM choke, both L_2 and L_3 represent 1mH inductance, C_1, C_2 and C_3 signify 0.01μF, 10nF and 1nF, respectively.
2. 10nF capacitor is shunt between the power supply of the carrier module to HF noises.

Due to the above methods, the CE of the power concentrator can pass EN 55022 Class B, where the average noises are 35dBμV@13.56MHz and 41dBμV@27.12MHz. And the safety margin of the power concentrator can reach 10dBμV, as shown in Fig.10(d).

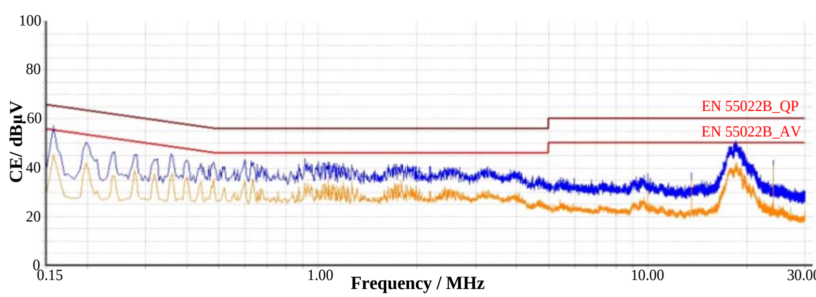
(a). *The power concentrator*



(b). *The original CE result*



(c). *EMI filter for the SMPS of the colonoscopy*



(d). *The final CE result based on the proposed method*

Fig.10: CE experiment of SMPS for the power concentrator

b) SMPS of the colonoscopy

The original CE result of the colonoscopy is shown in Fig.11(a),(b), and the noise can't pass EN 55022 Class B, as shown in Tab.3.

© 2017 Global Journals Inc. (US)

Tab. 3: The Original CE of the colonoscopy

Freuqency/MHz	Average/dBμV	Exceed/dBμV
0.16	66.42	1.42
0.18	67.02	3.02
0.22	68.01	5.03
0.24	65.01	3.01
0.26	65.02	4.11
0.30	64.96	5.04
0.32	65.04	6.16
0.34	63.95	5.82

Based on the present approach, the suppression methods are designed as follows:

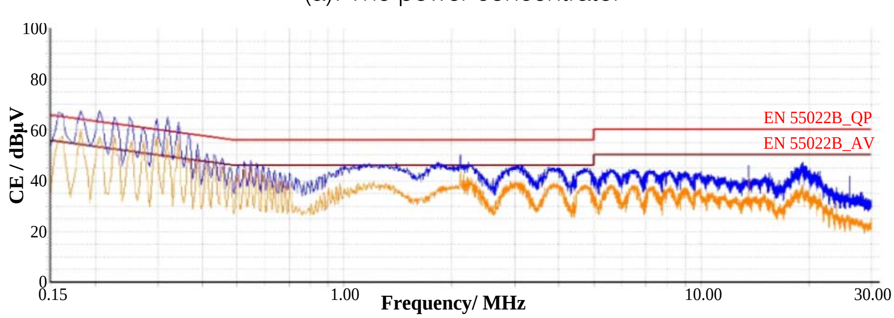
1. T model EMI filter is designed for SMPS of the colonoscopy, as shown in Fig.11(c), where L_1 and L_2 denote 35μH and 1.36μH crosstalk chokes, respectively, C represents 0.022μF capacitor.
2. L model EMI filter is also designed for the DC power conversion chip, where the inductance is 1.2μH and the capacitor is 0.15μF.

Due to the above methods, the CE of the colonoscopy can pass EN 55022 Class B, where the average noises are shown in Tab.4. And the safety margin of the colonoscopy can also reach 10dBμV, as shown in Fig.11(d).

Tab. 4: The Final CE of the colonoscopy

Freuqency/MHz	Average/dBμV	Decline/dBμV
0.16	50.20	16.22
0.18	49.96	17.06
0.22	42.62	25.39
0.24	44.88	20.13
0.26	42.16	22.86
0.30	39.92	25.04
0.32	43.81	21.23
0.34	40.68	23.27

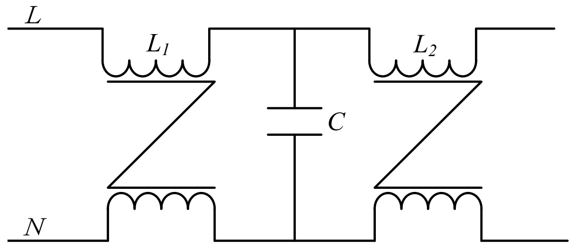
(a). The power concentrator



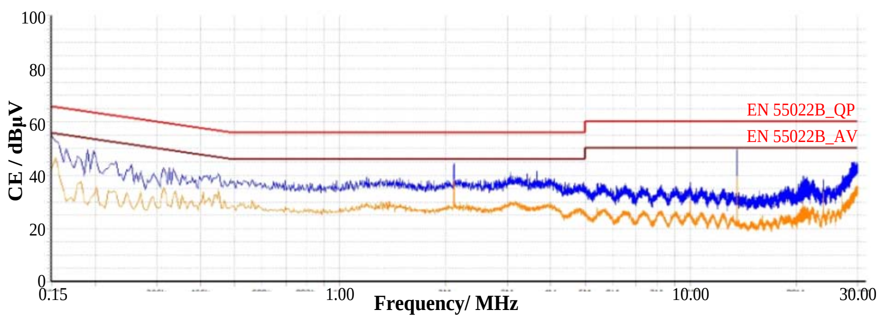
(b). The original CE result

Global Journal of Researches in Engineering (F) Volume XVII Issue II Version I Year 2017

017 Global Journals Inc. (US)



(c). EMI filter for the SMPS of the colonoscopy



(d). The final CE result based on the proposed method

Fig.11: CE experiment of SMPS for the colonoscopy

VII. Conclusion

In this paper, CE mechanism generated from the special two line SMPS is analyzed to solve the safety and EMI problem of SMPS. Following conclusions are obtained.

1) The voltage division factor, isolation factor and impedance under SMPS side were analyzed based on the HF parasitic parameters, which can improve the CE measurement uncertainty.
2) The CM and DM models for the two line SMPS were established due to the balanced and unbalanced current.
3) Three CE noise mitigation methods were proposed in the paper, such as the capacitor shunt between the source and drain electrodes of MOSFET, CM choke and crosstalk choke, and the capacitors matrix, which can improve the safety and EMI performance of SMPS.

The experiment results show that the CE noises of the power concentrator and colonoscopy can be reduced very well by employing the present approaches.

VIII. Acknowledgment

This paper is supported by Project Supported by National Natural Science Foundation of China (51475246); National Natural Science Foundation of Jiangsu Province(BK20161019); University Science Research Project of Jiangsu Province (15KJB470011).

References Références Referencias

1. Clayton R. Paul, Introduction to Electromagnetic Compatibility (Second Edition), *Hoboken, U.S.A: John Wiley & Sons, Inc*, (2006), 326-343.
2. Henry W. Ott, Electromagnetic Compatibility Engineering, *Hoboken, U.S.A: John Wiley & Sons, Inc*, (2009), 6-42.
3. Attaianese C., Nardi V., Tomasso G., EMC of power converters: The self-compatibility approach, *IET Electric Power Applications*, **1**(6) (2007), 862-869.
4. Wei Yan, Qiang Tang, Enrong Wang, Radiated emission mechanism for semi-active control strategy of magneto-rheological damper, *International Journal of Applied Electromagnetics and Mechanics*, **51**(2) (2016), 185-198.
5. Wei Yan, Jing Yu, Qiang Tang, Analysis and mitigation on conducted electromagnetic interference of semi-active control strategy for magneto-rheological damper, *International Journal of Applied Electromagnetics and Mechanics*, **50**(2) (2016), 247-254.
6. European Committee for Electrotechnical Standardization, EN 55022-2010: Information technology equipment- Radio disturbance characteristics- Limits and methods of measurement, *Brussels, Belgium: The European Commission and the European Free Trade Association*, (2010).
7. Chang Y.H., Complex programmable logic device-based closed-loop implementation of switched-

© 2017 Global Journals Inc. (US)

capacitor step-down DC-DC converter for multiple output choices, *IET Electric Power Applications*, **1**(6) (2007), 926-936.
8. Xiaopeng Dong, Haixiao Weng, Beetner D.G., Hubing T.H., Approximation of Worst Case Crosstalk at High Frequencies, *Electromagnetic Compatibility, IEEE Transactions on*, **53**(1) (2011), 202-208.
9. Yan Wei, Zhao Yang, Wang Enrong, et a, Investigation and Reduction on Conducted Electromagnetic Interference Noise Mechanism for Complex Power Electronics Systems, *Proceedings of the CSEE*, **32**(30) (2012), 156-162.
10. L.H. Kim，J.S. Yu，W.C. Lee, et al, Conducted EMI reduction of PWM inverter for AC motor drive systems, *International Journal of Applied Electromagnetics and Mechanics*, **24**(3) (2006), 195-207.
11. X. Wang，Z. Liu，Z. Zhou, Rapid computation model for accurate evaluation of electromagnetic interference shielding effectiveness of fabric with hole based on equivalent coefficient, *International Journal of Applied Electromagnetics and Mechanics*, **47**(1) (2015), 177-185.
12. See Kye Yak, Network for conducted EMI diagnosis, *Electronic Letter*, **35**(17) (1999), 1446-1447.
13. Mardiguian M., An alternative method for characterizing EMI filter, *IEEE International Symposium on Electromagnetic Compatibility*, **2** (1999), 882-886.
14. Ting Guo, Chen D.Y., Separation of the common-mode and differential-mode conducted EMI noise, *IEEE Transaction on Power electronics*, **11**(3) (1996), 480-488.
15. Bhargava A., Pommerenke D., Kam K.W. et al, DC-DC Buck Converter EMI Reduction Using PCB Layout Modification, *Electromagnetic Compatibility, IEEE Transactions on*, **53**(3) (2011), 806-813.
16. Mukherjee R., Patra A., Banerjee S., Impact of a Frequency Modulated Pulsewidth Modulation (PWM) Switching Converter on the Input Power System Quality, *Power Electronics, IEEE Transactions on*, **25**(6) (2010), 1450-1459.
17. Tripathi J.N., Mukherjee J., Apte P.R., et al, Selection and placement of decoupling capacitors in high speed systems, *Electromagnetic Compatibility Magazine, IEEE*, **2**(4) (2013), 72-78.
18. Wu W., Sun Y., Lin Z. et al, A Modified LLCL Filter With the Reduced Conducted EMI Noise, *Power Electronics, IEEE Transactions on*, **29**(7) (2014), 3393-3402.
19. Lei Xing, Jian Sun, Conducted Common-Mode EMI Reduction by Impedance Balancing, *Power Electronics, IEEE Transactions on*, **27**(3) (2012), 1084-1089.

© 2017 Global Journals Inc. (US)

This page is intentionally left blank

© 2017 Global Journals Inc. (US)

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 17 Issue 2 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Low Probability of Intercept Triangular Modulated Frequency Modulated Continuous Wave Signal Characterization Comparison using the Spectrogram and the Scalogram

By Daniel L. Stevens & Stephanie A. Schuckers

Air Force Research Laborator

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

GJRE-F Classification: FOR Code: 090609

LOWPROBABILITYOFINTERCEPTTRIANGULARMODULATEDFREQUENCYMODULATEDCONTINUOUSWAVESIGNALCHARACTERIZATIONCOMPARISONUSINGTHESPECTROGRAMANDTHESCALOGRAM

Strictly as per the compliance and regulations of :

Research | Diversity | Ethics

© 2017. Daniel L. Stevens & Stephanie A. Schuckers. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecom mons.org/ licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Low Probability of Intercept Triangular Modulated Frequency Modulated Continuous Wave Signal Characterization Comparison using the Spectrogram and the Scalogram[1]

Daniel L. Stevens [α] & Stephanie A. Schuckers [σ]

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

I. Introduction

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

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

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

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

The Spectrogram is defined as the magnitude squared of the Short-Time Fourier Transform (STFT) [HIP00], [HLA92], [MIT01], [PAC09], [BOA03]. For non-stationary signals, the STFT is usually in the form of the Spectrogram [GRI08].

The STFT of a signal x(u) is given in equation 1 as:

$$F_x(t,f;h) = \int_{-\infty}^{+\infty} x(u)h\,(u-t)e^{-j2\pi f u}du \qquad (1)$$

Where h(t) is a short time analysis window localized around t=0 and f=0. Because multiplication by the relatively short window h(u-t) effectively suppresses the signal outside a neighborhood around the analysis point u=t, the STFT is a 'local' spectrum of the signal x(u) around t. Think of the window h(t) as sliding along the signal x(u) and for each shift h(u-t) we compute the usual Fourier transform of the product function x(u)h(u-t). The observation window allows

Author α: Air Force Research Laboratory Rome, NY 13441. e-mail: daniel.stevens.7@us.af.mil
Auhtor σ: Department of Electrical and Computer Engineering, Clarkson University Potsdam, NY 13699. e-mail: sschucke@clarkson.edu

[1] Approved for Public Release; Distribution Unlimited: CaseNumber: 88ABW-2017-1873, 25-Apr-2017

Global Journal of Researches in Engineering (F) Volume XVII Issue II Version I Year 2017

© 2017 Global Journals Inc. (US)

localization of the spectrum in time, but also smears the spectrum in frequency in accordance with the uncertainty principle, leading to a trade-off between time resolution and frequency resolution. In general, if the window is short, the time resolution is good, but the frequency resolution is poor, and if the window is long, the frequency resolution is good, but the time resolution is poor.

The STFT was the first tool devised for analyzing a signal in both time and frequency simultaneously. For analysis of human speech, the main method was, and still is, the STFT. In general, the STFT is still the most widely used method for studying non-stationary signals [COH95].

The Spectrogram (the squared modulus of the STFT) is given by equation 2 as:

$$S_x(t,f) = \left|\int_{-\infty}^{+\infty} x(u)\, h(u-t) e^{-j2\pi f u} du\right|^2 \qquad (2)$$

The Spectrog ram is a real-valued and non-negative distribution. Since the window h of the STFT is assumed of unit energy, the Spectrogram satisfies the global energy distribution property. Thus we can interpret the Spectrogram as a measure of the energy of the signal contained in the time-frequency domain centered on the point (t, f) and whose shape is independent of this localization.

Here are some properties of the Spectrogram:

1) *Time and Frequency covariance*- The Spectrogram preserves time and frequency shifts, thus the spectrogram is an element of the class of quadratic time-frequency distributions that are covariant by translation in time and in frequency (i.e. Cohen's class);
2) *Time-Frequency Resolution*- The time-frequency resolution of the Spectrogram is limited exactly as it is for the STFT; there is a trade-off between time resolution and frequency resolution;
3) *Interference Structure*- As it is a quadratic (or bilinear) representation, the Spectrogram of the sum of two signals is not the sum of the two Spectrograms (quadratic superposition principle); there is a cross-Spectrogram part and a real part. Thus, as for every quadratic distribution, the Spectrogram presents interference terms; however, those interference terms are restricted to those regions of the time-frequency plane where the signals overlap. Thus if the signal components are sufficiently distant so that their Spectrograms do not overlap significantly, then the interference term will nearly be identically zero [ISI96], [COH95], [HLA92].

The Scalogram is defined as the magnitude squared of the wavelet transform, and can be used as a time-frequency distribution [COH02], [GAL05], [BOA03].

The idea of the wavelet transform (equation (3)) is to project a signal x on a family of zero-mean functions (the wavelets) deduced from an elementary function (the mother wavelet) by translations and dilations:

$$T_x(t,a;\Psi) = \int_{-\infty}^{+\infty} x(s)\Psi_{t,a}^*(s)ds \qquad (3)$$

where $\Psi_{t,a}(s) = |a|^{-1/2}\Psi\left(\frac{s-t}{a}\right)$. The variable a corresponds to a scale factor, in the sense that taking |a|>1 dilates the wavelet Ψ and taking |a|<1 compresses Ψ. By definition, the wavelet transform is more a time-scale than a time-frequency representation. However, for wavelets which are well localized around a non-zero frequency ν_0 at a scale =1 , a time-frequency interpretation is possible thanks to the formal identification $\nu = \frac{\nu_0}{a}$.

The wavelet transform is of interest for the analysis of non-stationary signals, because it provides still another alternative to the STFT and to many of the quadratic time-frequency distributions. The basic difference between the STFT and the wavelet transform is that the STFT uses a fixed signal analysis window, whereas the wavelet transform uses short windows at high frequencies and long windows at low frequencies. This helps to diffuse the effect of the uncertainty principle by providing good time resolution at high frequencies and good frequency resolution at low frequencies. This approach makes sense especially when the signal at hand has high frequency components for short durations and low frequency components for long durations. The signals encountered in practical applications are often of this type.

The wavelet transform allows localization in both the time domain via translations of the mother wavelet, and in the scale (frequency) domain via dilations. The wavelet is irregular in shape and compactly supported, thus making it an ideal tool for analyzing signals of a transient nature; the irregularity of the wavelet basis lends itself to analysis of signals with discontinuities or sharp changes, while the compactly supported nature of wavelets enables temporal localization of a signal's features [BOA03]. Unlike many of the quadratic functions such as the Wigner-Ville Distribution (WVD) and Choi-Williams Distribution (CWD), the wavelet transform is a linear transformation, therefore cross-term interference is not generated. There is another major difference between the STFT and the wavelet transform; the STFT uses sines and cosines as an orthogonal basis set to which the signal of interest is effectively correlated against, whereas the wavelet transform uses special 'wavelets' which usually comprise an orthogonal basis set. The wavelet transform then computes coefficients, which represents a measure of the similarities, or correlation, of the signal with respect to the set of wavelets. In other words, the wavelet transform of a signal corresponds to its decomposition with respect to a family of functions obtained by dilations (or

© 2017 Global Journals Inc. (US)

contractions) and translations (moving window) of an analyzing wavelet.

A filter bank concept is often used to describe the wavelet transform. The wavelet transform can be interpreted as the result of filtering the signal with a set of bandpass filters, each with a different center frequency [GRI08], [FAR96], [SAR98], [SAT98].

Like the design of conventional digital filters, the design of a wavelet filter can be accomplished by using a number of methods including weighted least squares [ALN00], [GOH00], orthogonal matrix methods [ZAH99], nonlinear optimization, optimization of a single parameter (e.g. the passband edge) [ZHA00], and a method that minimizes an objective function that bounds the out-of-tile energy [FAR99].

Here are some properties of the wavelet transform: 1) The wavelet transform is covariant by translation in time and scaling. The corresponding group of transforms is called the Affine group; 2) The signal x can be recovered from its wavelet transform via the synthesis wavelet; 3) Time and frequency resolutions, like in the STFT case, are related via the Heisenberg-Gabor inequality. However in the wavelet transform case, these two resolutions depend on the frequency: the frequency resolution becomes poorer and the time resolution becomes better as the analysis frequency grows; 4) Because the wavelet transform is a linear transform, it does not contain cross-term interferences [GRI07], [LAR92].

A similar distribution to the Spectrogram can be defined in the wavelet case. Since the wavelet transform behaves like an orthonormal basis decomposition, it can be shown that it preserves energy:

$$\iint_{-\infty}^{+\infty} |T_x(t,a;\Psi)|^2 \; dt\frac{da}{a^2} = E_x \qquad (4)$$

where E_x is the energy of x. This leads us to define the Scalogram (equation (4)) of x as the squared modulus of the wavelet transform. It is an energy distribution of the signal in the time-scale plane, associated with the measure $\frac{da}{a^2}$.

As is the case for the wavelet transform, the time and frequency resolutions of the Scalogram are related via the Heisenberg-Gabor principle.

The interference terms of the Scalogram, as for the spectrogram, are also restricted to those regions of the time-frequency plane where the corresponding signals overlap. Therefore, if two signal components are sufficiently far apart in the time-frequency plane, their cross-Scalogram will be essentially zero [ISI96], [HLA92].

For this paper, the Morlet Scalogram will be used. The Morlet wavelet is obtained by taking a complex sine wave and by localizing it with a Gaussian envelope. The Mexican hat wavelet isolates a single bump of the Morlet wavelet. The Morlet wavelet has good focusing in both time and frequency [CHE09].

II. Methodology

The methodologies detailed in this section describe the processes involved in obtaining and comparing metrics between the classical time-frequency analysis techniques of the Spectrogram and the Scalogram for the detection and characterization of low probability of intercept triangular modulated FMCW radar signals.

The tools used for this testing were: MATLAB (version 7.12), Signal Processing Toolbox (version 6.15), Wavelet Toolbox (version 4.7), Image Processing Toolbox (version 7.2), Time-Frequency Toolbox (version 1.0) (http://tftb.nongnu.org/).

All testing was accomplished on a desktop computer (HP Compaq, 2.5GHz processor, AMD Athlon 64X2 Dual Core Processor 4800+, 2.00GB Memory (RAM), 32 Bit Operating System).

Testing was performed for 2 different triangular modulated FMCW waveforms. For each waveform, parameters were chosen for academic validation of signal processing techniques. Due to computer processing resources they were not meant to represent real-world values. The number of samples for each test was chosen to be either 256 or 512, which seemed to be the optimum size for the desktop computer. Testing was performed at three different SNR levels: 10dB, 0dB, and the lowest SNR at which the signal could be detected. The noise added was white Gaussian noise, which best reflects the thermal noise present in the IF section of an intercept receiver [PAC09]. Kaiser windowing was used, when windowing was applicable. 50 runs were performed for each test, for statistical purposes. The plots included in this paper were done at a threshold of 5% of the maximum intensity and were linear scale (not dB) of analytic (complex) signals; the color bar represented intensity. The signal processing tools used for each task were the Spectrogram and the Scalogram.

Task 1 consisted of analyzing a triangular modulated FMCW signal (most prevalent LPI radar waveform [LIA09]) whose parameters were: sampling frequency=4KHz; carrier frequency=1KHz; modulation bandwidth=500Hz; modulation period=.02sec.

Task 2 was similar to Task 1, but with different parameters: sampling frequency=6KHz; carrier frequency=1.5KHz; modulation bandwidth=2400Hz; modulation period=.15sec. The different parameters were chosen to see how the different shapes/heights of the triangles of the triangular modulated FMCW would affect the metrics.

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

1) Plot (processing) time: Time required for plot to be displayed.

© 2017 Global Journals Inc. (US)

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

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

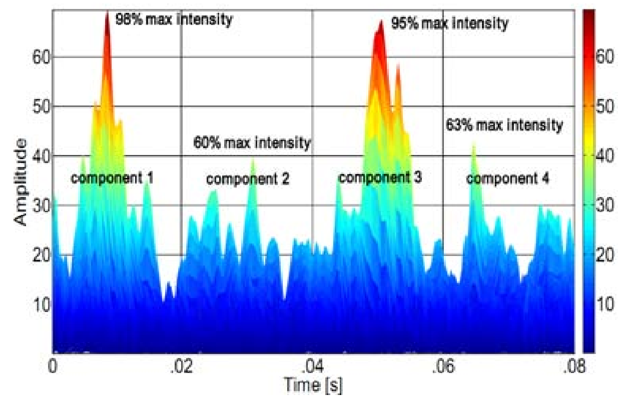


Figure 1: Threshold percentage determination. This plot is an amplitude vs. time (x-z view) of the Spectrogram of a triangular modulated FMCW signal (256 samples, with SNR= -3dB). For visually detected low SNR plots (like this one), the percent of max intensity for the peak z-value of each of the signal components (the 2 legs for each of the 2 triangles of the triangular modulated FMCW) was noted (here 98%, 60%, 95%, 63%), and the lowest of these 4 values was recorded (60%). Ten test runs were performed for both time-frequency analysis tools (Spectrogram and Scalogram) for this waveform. The average of these recorded low values was determined and then assigned as the threshold for that particular time-frequency analysis tool. Note - the threshold for the Spectrogram is 60%.

Thresholds were assigned as follows: Spectrogram (60%); Scalogram (50%).

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

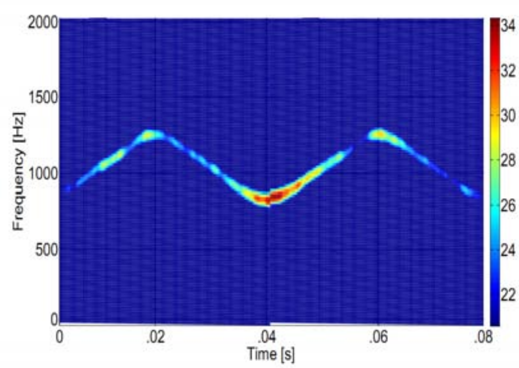


Figure 2: Percent detection (time-frequency). This plot is an frequency vs. time (x-y view) of the Spectrogram of a triangular modulated FMCW signal (256 samples, with SNR= 10dB) with threshold value automatically set to 60%. From this threshold plot, the signal was declared a (visual) detection because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

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

© 2017 Global Journals Inc. (US)

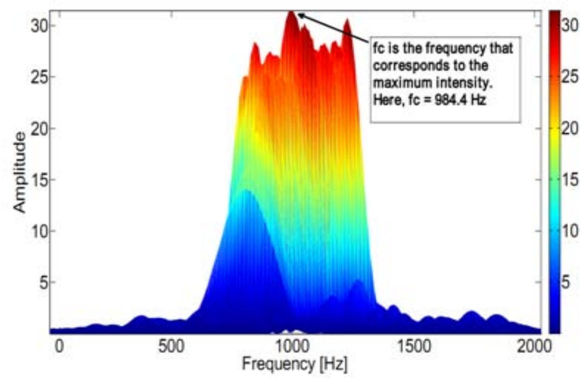


Figure 3: Determination of carrier frequency. Spectrogram of a triangular modulated FMCW signal (256 samples, SNR=10dB). From the frequency-intensity (y-z) view, the maximum intensity value is manually determined. The frequency corresponding to the max intensity value is the carrier frequency (here fc=984.4 Hz).

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

The threshold percentage was determined based on manual measurement of the modulation bandwidth of the signal in the time-frequency representation. This was accomplished for ten test runs of each time-frequency analysis tool (Spectrogram and Scalogram), for each of the 2 waveforms. During each manual measurement, the max intensity of the high and low measuring points was recorded. The average of the max intensity values for these test runs was 20%. This was adopted as the threshold value, and is representative of what is obtained when performing manual measurements. This 20% threshold was also adapted for determining the modulation period and the time-frequency localization (both are described below).

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

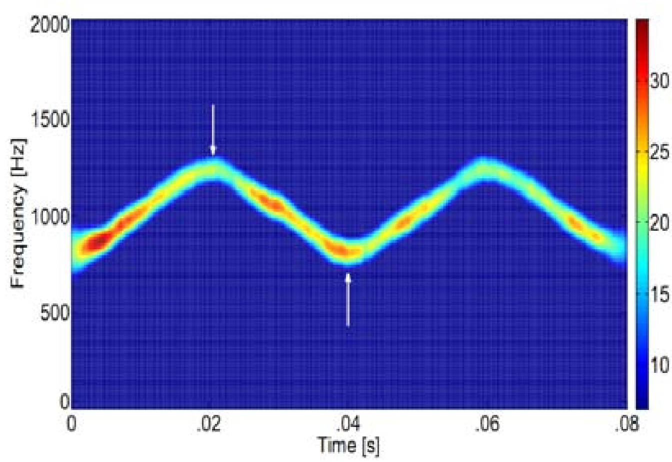


Figure 4: Modulation bandwidth determination. Spectrogram of a triangular modulated FMCW signal (256 samples, SNR=10dB) with threshold value automatically set to 20%. From this threshold plot, the modulation bandwidth was measured manually from the highest frequency value of the signal (top white arrow)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

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

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

© 2017 Global Journals Inc. (US)

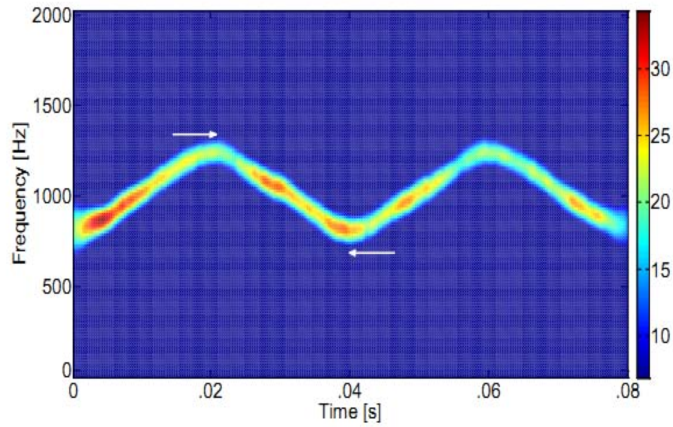


Figure 5: Modulation period determination. Spectrogram of a triangular modulated FMCW signal (256 samples, SNR=10dB) with threshold value automatically set to 20%. From this threshold plot, the modulation period was measured manually from the highest frequency value of the signal (top white arrow) to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

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

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

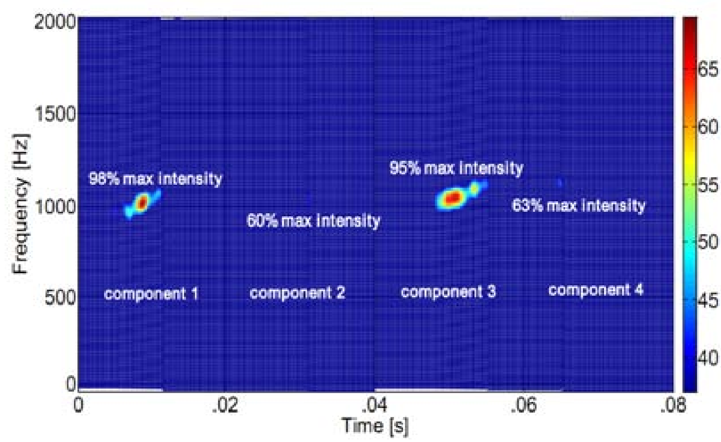


Figure 6: Time-frequency localization determination. Spectrogram of a triangular modulated FMCW signal (256 samples, SNR=10dB) with threshold value automatically set to 20%. From this threshold plot, the time-frequency localization was measured manually from the left side of the signal (left white arrow)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

7) Chirp rate: (modulation bandwidth)/(modulation period)

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

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

© 2017 Global Journals Inc. (US)

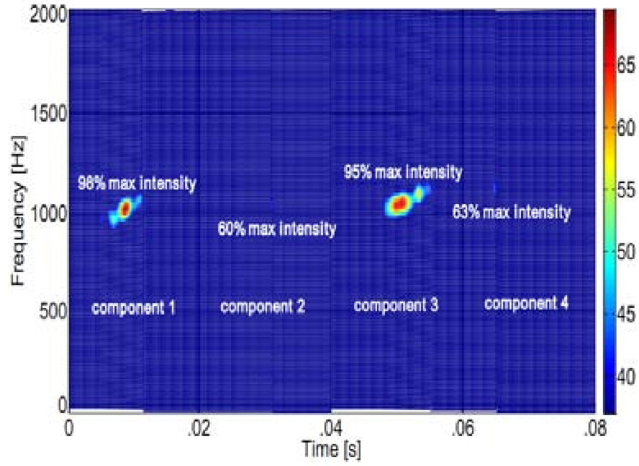


Figure 7: Lowest detectable SNR. This plot is an frequency vs. time (x-y view) of the Spectrogram of a triangular modulated FMCW signal (256 samples, with SNR= -3dB) with threshold value automatically set to 60%. From this threshold plot, the signal was declared a (visual) detection because at least a portion of each of the 4 signal components (the 2 legs for each of the 2 triangles of the triangular modulated FMCW) was visible. Note that the signal portion for the 60% max intensity (just above the 'x' in 'max') is barely visible, because the threshold for the Spectrogram is 60%. For this case, any lower SNR would have been a non-detect. Compare to Figure 2, which is the same plot, except that it has an SNR level equal to 10dB.

The data from all 50 runs for each test was used to produce the actual, error, and percent error for each of these metrics listed above.

The metrics from the Spectrogram were then compared to the metrics from the Scalogram. By and large, the Spectrogram outperformed the Scalogram, as will be shown in the results section.

III. Results

Table 1 presents the overall test metrics for the two classical time-frequency analysis techniques used in this testing (Spectrogram versus Scalogram).

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

parameters	Spectrogram	Scalogram
carrier frequency	6.83%	8.26%
modulation bandwidth	16.60%	28.17%
modulation period	0.68%	0.72%
chirp rate	16.25%	28.47%
percent detection	70.0%	62.22%
lowest detectable snr	-3.67db	-2.67db
plot time	3.28s	4.16s
time-frequency localization-x	2.88%	4.51%
time-frequency localization-y	5.75%	9.0%

From Table 1, the Spectrogram outperformed the Scalogram in every metrics category.

Figure 8 shows comparative plots of the Spectrogram (left) vs. the Scalogram (right) (triangular

Global Journal of Researches in Engineering (F) Volume XVII Issue II Version I Year 2017

© 2017 Global Journals Inc. (US)

modulated FMCW signal – Task 1) at SNRs of 10dB (top), 0dB (middle), and -3dB (bottom).

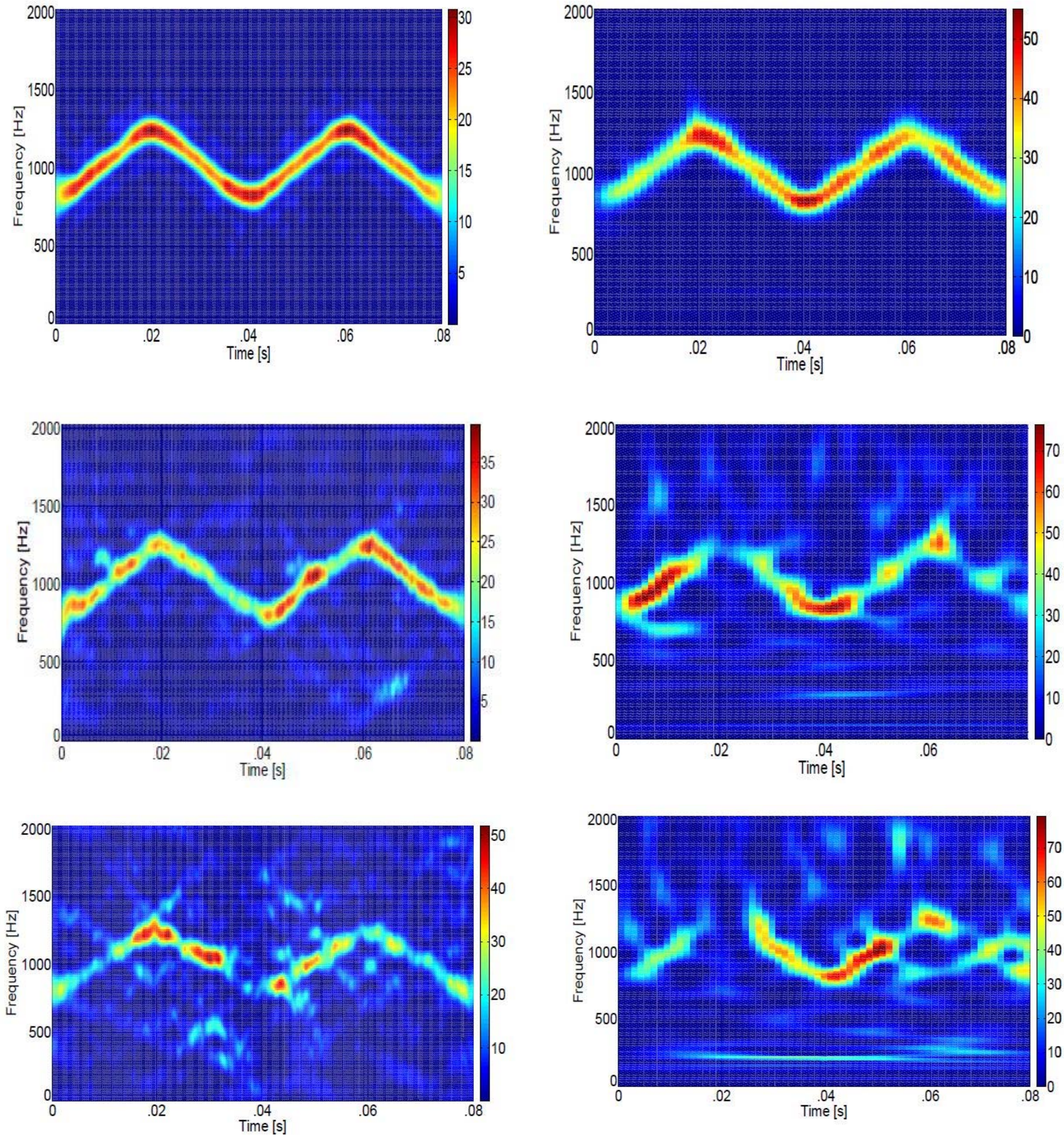


Figure 8: Comparative plots of the triangular modulated FMCW (task 1) low probability of intercept radar signals (Spectrogram (left-hand side) vs. the Scalogram (right-hand side)). The SNR for the top row is 10dB, for the middle row is 0dB, and for the bottom row is -3dB. In general, the Spectrogram signals appear more localized ('thinner') than do the Scalogram signals. In addition, the Spectrogram signals appear more readable than the Scalogram signals at every SNR level.

Figure 9 shows comparative plots of the Spectrogram (left) vs. the Scalogram (right) (triangular modulated FMCW signal – Task 2) at SNRs of 10dB (top), 0dB (middle), and -3dB (bottom).

© 2017 Global Journals Inc. (US)

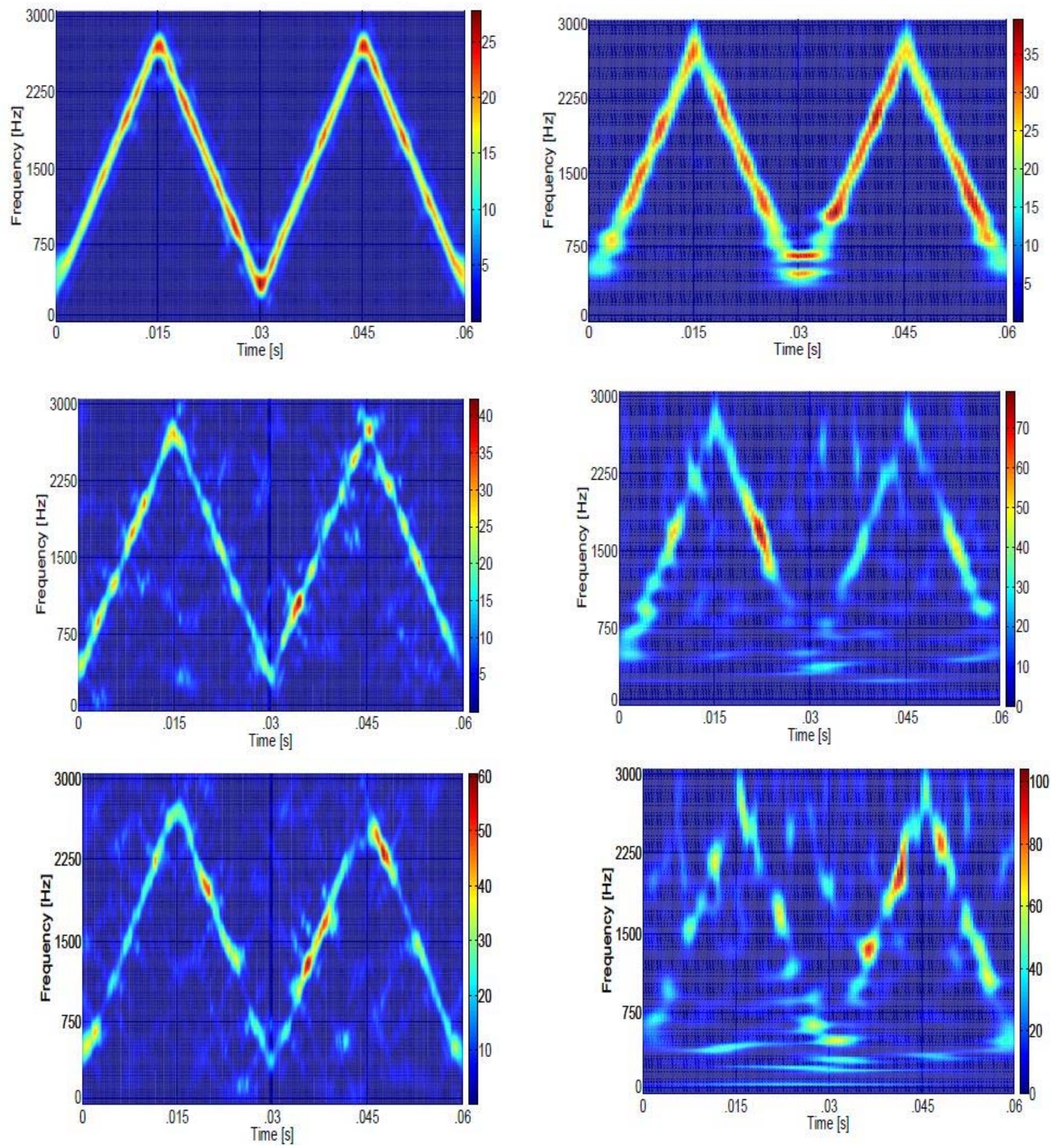


Figure 9: Comparative plots of the triangular modulated FMCW (task 2) low probability of intercept radar signals (Spectrogram (left-hand side) vs. the Scalogram (right-hand side)). The SNR for the top row is 10dB, for the middle row is 0dB, and for the bottom row is -3dB. In general, the Spectrogram signals appear more localized ('thinner') than do the Scalogram signals. In addition, the Spectrogram signals appear more readable than the Scalogram signals at every SNR level.

IV. Discussion

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

From Table 1, the Spectrogram outperformed the Scalogram in every category. The Spectrogram's reduction of cross-term interference is grounds for its better plot time. Average percent detection and lowest detectable SNR are both based on visual detection in the Time-Frequency representation. Figure 8 and Figure 9 show clearly that the signals in the Spectrogram plots are more readable than those in the Scalogram plots, which account for the Spectrogram's better average percent detection and lowest detectable SNR. At relatively low frequencies (as in this paper), wavelets (Scalograms), because of their multi-resolution analysis basis, are better resolved (localized) in frequency and

© 2017 Global Journals Inc. (US)

more poorly resolved (localized) in time. Therefore for relatively low frequencies, the best waveforms to be analyzed by wavelets (Scalograms) are tonals. In addition, the irregularity of the wavelet (Scalogram) basis lends itself to analysis of signals with discontinuities (such as frequency hopping signals (tonals)). Also, since the wavelet is irregular in shape and compactly supported, it makes it an ideal tool for analyzing signals of transient nature (such as the frequency hopping signals (tonals)). Therefore as the signal goes from being 'flat' (i.e. a tonal) signal, to more 'upright' (i.e. a triangular modulated FMCW) signal, the Scalogram of this signal becomes more poorly resolved (localized), i.e. 'fatter', accounting for the Scalogram's poorer metrics in the categories of modulation bandwidth, modulation period, chirp rate, carrier frequency, time-frequency localization (x), and time-frequency localization (y).

V. Conclusions

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

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

References Références Referencias

1. [ALN00] Al-Namiy, F., Nigam, M., On the Design of 2-Band FIR QMF Filter Banks Using WLS Techniques. Proceedings of the Fourth IEEE International Conference on High Performance Computing in the Asia-Pacific Region, Vol. 2, pp. 772-776, May 2000.
2. [ANJ09] Anjaneyulu, L., Murthy, N., Sarma, N., A Novel Method for Recognition of Modulation Code of LPI Radar Signals. International Journal of Recent Trends in Engineering, Vol. 1, No. 3, pp. 176-180, May 2009.
3. [BOA03] Boashash, B., Time Frequency Signal Analysis and Processing: A Comprehensive Reference. Elsevier, Oxford, England, 2003.
4. [CHE09] Chen, C., He, M., Jin, H., Li, H., Shen, Z., A Novel Method for Extraction of In-Pulse Feature of Multi-Component LFM Signal. ICEMI 2009, pp. 4-627 – 4-630, 2009.
5. [COH02] Cohen, L., The Wavelet Transform and Time-Frequency Analysis. in: Debnath, L., Wavelet Transforms and Signal Processing, Birkhauser, pp. 3-22, 2002.
6. [COH95] Cohen, L., Time-Frequency Analysis. Prentice Hall, Upper Saddle River, NJ, 1995.
7. [FAR96] Farrell, T.C., Prescott, G., A Low Probability of Intercept Signal Detection Receiver Using Quadrature Mirror Filter Bank Trees. IEEE Proceedings, pp. 1558-1561, 1996.
8. [FAR99] Farrell, T., Prescott, G., A Method for Finding Orthogonal Wavelet Filters with Good Energy Tiling Characteristics. IEEE Transactions on Signal Processing, Vol. 47, No. 1, pp. 220-223, Jan. 1999.
9. [GAL05] Galleani, L., Cohen, L., Noga, A., A Time-Frequency Approach to the Adjustable Bandwidth Concept. Digital Signal Processing, Vol. 16, Issue 5, pp. 454-467, Sept. 2006.
10. [GOH00] Goh, C., Lim, T., A WLS Algorithm for the Design of Low-Delay Quadrature Mirror Filter Banks. Proceedings of the IEEE International Symposium on Circuits and Systems, Vol. 1, pp. 615-618, May 2000.
11. [GRI07] Grishin, Y., Janczak, D., Computer-Aided Methods of the LPI Radar Signal Detection and Classification. Proc. of SPIE Vol. 6937, pp. 1-5, 2007.
12. [GRI08] Grishin, Y., Interferences Excision Via Time-Frequency Distribution in Radio Communication Systems. EMD 2008, XVIII-th International Conference on Electromagnetic Disturbances, Vilnius, Lithuania, pp. 85-88, 25-26 September 2008.
13. [GUL08] Gulum, T., Pace, P., Cristi, R., Extraction of Polyphase Radar Modulation Parameters Using a Wigner-Ville Distribution-Radon Transform. IEEE International Conference on Acoustics, Speech, and Signal Processing, Las Vegas, NV, April 2008.
14. [HAN00] Han, S., Hong, H., Seo, D., Choi, J., Target Position Extraction Based on Instantaneous Frequency Estimation in a Fixed-Reticle Seeker. Opt. Eng., Vol. 39, pp. 2568-2573, September 2000.
15. [HIP00] Hippenstiel, R., Fargues, M., Moraitakis, I., Williams, C., Detection and Parameter Estimation of Chirped Radar Signals. Final Report, Naval Postgraduate School, Monterey, CA, Jan. 10, 2000.

© 2017 Global Journals Inc. (US)

16. [HLA92] Hlawatsch, F., Boudreaux-Bartels, G.F., Linear and Quadratic Time-Frequency Signal Representations. IEEE Signal Processing Mag., Vol. 9, No. 2, pp. 21-67, April 1992.
17. [ISI96] Auger, F., Flandrin, P., Goncalves, P., Lemoine, O., Time-Frequency Toolbox Users Manual. Centre National de la Recherche Scientifique and Rice University, 1996.
18. [LAR92] Lari, F., Zakhor, A., Automatic Classification of Active Sonar Data Using Time-Frequency Transforms. Proceedings of IEEE-SP International Symposium on Time-Frequency and Time-Scale Analysis, Victoria, BC, pp. 21-24, Oct. 4-6, 1992.
19. [LIA09] Liang, Y., Zhang, L., Xing, M., Bao, Z., High-Speed Ground Moving Target Detection Research Using Triangular Modulation FMCW. Front. Electr. Electron. Eng., China, 4(2), pp. 127-133, 2009.
20. [LIW08] Li, W., Dan, M., Wang, X., Li, D., Wang, G., Fast Estimation Method and Performance Analysis of Frequency Modulation Rate Via RAT. Proceedings of the 2008 IEEE International Conference on Information and Automation, Zhangjiajie, China, pp. 144-147, June 20-23, 2008.
21. [LIX08] Li, X., Bi, G., A New Reassigned Time-Frequency Representation. 16th European Signal Processing Conference, Lausanne, Switzerland, pp. 1-4, August 25-29, 2008.
22. [LIY03] Li, Y., Xiao, X., Recursive Filtering Radon-Ambiguity Transform Algorithm for Detecting Multi-LFM Signals. Journal of Electronics (China), Vol. 20, No. 3, pp. 161-166, May 2003.
23. [MIL02] Milne, P., Pace, P., Wigner Distribution Detection and Analysis of FMCW and P-4 Polyphase LPI Waveforms. Proceedings of ICASSP, Orlando, FL, pp. 3944-3947, 2002.
24. [MIT01] Mitra, S., Digital Signal Processing, A Computer-Based Approach, Second Edition. McGraw-Hill, Boston, MA, 2001.
25. [OZD03] Ozdemir, A., Time-Frequency Component Analyzer. Dissertation, Bilkent University, Ankara, Turkey, Sept. 2003.
26. [PAC09] Pace, P., Detecting and Classifying Low Probability of Intercept Radar. Artech House, Norwood, MA, 2009.
27. [PAP95] Papandreou, A., Boudreaux-Bartels, G.F., Kay, S., Detection and Estimation of Generalized Chirps Using Time-Frequency Representations. 1994 Conference Record of the Twenty-Eighth Asilomar Conference on Signals, Systems and Computers, pp. 50-54, 1994.
28. [RAN01] Rangayyan, R., Krishnan, S., Feature Identification in the Time-Frequency Plane by Using the Hough-Radon Transform. Pattern Recognition, Vol. 34, pp. 1147-1158, 2001.
29. [SAR98] Sarkar, T., Su, C., et al., A Tutorial on Wavelets from an Electrical Engineering Perspective, Part 1: Discrete Wavelet Techniques. IEEE Antennas and Propagation Magazine, Vol. 40, No. 5, pp. 49-70, October 1998.
30. [SAT98] Sarkar, T., Su, C., A Tutorial on Wavelets from an Electrical Engineering Perspective, Part 2: The Continuous Case. IEEE Antennas and Propagation Magazine, Vol. 40, No. 6, pp. 36-49, December 1998.
31. [WAJ08] Wang, Y., Jiang, Y., Detection and Parameter Estimation of Multicomponent LFM Signal Based on the Cubic Phase Function. EURASIP Journal on Advances in Signal Processing, Vol. 2008, Article ID 743985, pp. 1-7, 2008
32. [WAN10] Wang, P., Li, H., Djurovic, I., Himed, B., Integrated Cubic Phase Function for Linear FM Signal Analysis. IEEE Transactions on Aerospace and Electronic Systems, to appear, 2010.
33. [WEI03] Wei, G., Wu, S., Mao, E., Analysis of Multicomponent LFM Signals Using Time-Frequency and The Gray-Scale Inverse Hough Transform. IEEE Workshop on Statistical Signal Processing, pp. 190-193, September 28 – October 1, 2003.
34. [WIL06] Wiley, R., ELINT: The Interception and Analysis of Radar Signals. Artech House, Norwood, MA, 2006.
35. [WON09] Wong, K., Davidson, T., Abelkader, S., Detection of Low Probability of Intercept Radar Signals. Defence R&D Canada – Ottawa Contract Report 2009-142, September 2009.
36. [XIA99] Xia, X., Chen, V., A Quantitative SNR Analysis for the Pseudo Wigner-Ville Distribution. IEEE Transactions on Signal Processing, Vol. 47, No. 10, pp. 2891-2894, October, 1999.
37. [ZAH99] Zahhad, A., Sabah, M., Design of Selective M-Channel Perfect Reconstruction FIR Filter Banks. IEE Electronics Letters, Vol. 35, No. 15, pp. 1223-1225, 1999.
38. [ZHA00] Zhang, Z., Jiao, L., A Simple Method for Designing Pseudo QMF Banks. Proceedings of the IEEE International Conference on Communication Technology, Vol. 2, pp. 1538-1541, Aug. 2000.

© 2017 Global Journals Inc. (US)

This page is intentionally left blank

© 2017 Global Journals Inc. (US)

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 17 Issue 2 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Performance Analysis of Enhanced Carbon Nanotube Field Effect Transistor (CNTFET) using Zirconia as Gate Dielectric

By Faisal Al Mozahid, Dr. M Tanseer Ali & Md. Ashikur Rahman

American International University-Bangladesh

Abstract- The Carbon Nanotube Field Effect Transistor (CNTFET) is one of the most rising devices among the emerging technologies to extend and/or complement the traditional Silicon MOSFET as it is showing high efficiency and wide range of applications in many different fields of science and technology. Carbon Nanotube Field Effect Transistors have been explored and proposed to be the upcoming more efficient and suitable candidates for the integrated circuit (NGIC) devices of next generation. In this study, firstly, the Density of State (DOS) with different types of nanotubes considering the chirality have been reviewed. Then we have studied the carbon nanotube field effect transistor by replacing the traditional gate insulator with a material that has much higher dielectric constant.

Keywords: carbon nanotube, CNT field effect transistor, CNT DOS, Gate Dielectric.

GJRE-F Classification: FOR Code: 090699

PERFORMANCEANALYSISOFENHANCEDCARBONNANOTUBEFIELDEFFECTTRANSISTORCNTFETUSINGZIRCONIAASGATEDIELECTRIC

Strictly as per the compliance and regulations of :

© 2017. Faisal Al Mozahid, Dr. M Tanseer Ali & Md. Ashikur Rahman. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecom mons.org/ licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Performance Analysis of Enhanced Carbon Nanotube Field Effect Transistor (CNTFET) using Zirconia as Gate Dielectric

Faisal Al Mozahid [α], Dr. M Tanseer Ali [σ] & Md. Ashikur Rahman [ρ]

Abstract- The Carbon Nanotube Field Effect Transistor (CNTFET) is one of the most rising devices among the emerging technologies to extend and/or complement the traditional Silicon MOSFET as it is showing high efficiency and wide range of applications in many different fields of science and technology. Carbon Nanotube Field Effect Transistors have been explored and proposed to be the upcoming more efficient and suitable candidates for the integrated circuit (NGIC) devices of next generation. In this study, firstly, the Density of State (DOS) with different types of nanotubes considering the chirality have been reviewed. Then we have studied the carbon nanotube field effect transistor by replacing the traditional gate insulator with a material that has much higher dielectric constant. Carbon Nanotube Field Effect Transistor has been analyzed with the bandgap of 1.0882eV in this research and ZrO2 (Zirconia) has been taken as the gate dielectric. We have also analyzed quantum capacitance, transconductance and mobile charge behavior at different drain voltage. Finally, the output characteristics of proposed model has been given.

Keywords: carbon nanotube, CNT field effect transistor, CNT DOS, Gate Dielectric.

I. Introduction

Carbon Nanotubes are sheets of graphite rolled in the shape of a tube. Depending on chirality they can be either metallic or semiconducting. Carbon Nanotubes were discovered by Iijima at the NEC Fundamental Research Laboratory while he used a high resolution transmission electron microscope (TEM) to observe byproducts of carbon which had been generated by an arc between two carbon electrodes (Iijima, 1991). After that momentous development has been achieved by understanding the characteristics and searching possible applications of these on semiconductor technology. They have high elastic modulus, small weight and are predicted to be the strongest fibers. Carbon Nanotube's strength and flexibility are their unique properties. The fascinating electronic properties of them depend drastically on both the diameter and the chirality of the hexagonal carbon lattice along the tube (Mintmire *et al*., 1992; Hamada *et al*., 1992; Saito *et al*., 1992). Because of its excellent conductivity and high dielectric properties, CNTs play a vital role in different nano electronic devices such as transistors, digital logic devices, memory components, etc (Heinze *et al*., 2002).

The fundamental strategy for improving the performance of VLSIs is scaling down of electronic devices. According to the ITRS the gate length of MOSFETs will be less than 16 nm in 2016 (ITRS, 2003). If this continues then the MOSFETs will reach its limiting size very soon. Thus the semiconductor industry is searching for different materials to integrate with the current silicon-based technology and in the long run, possibly replace it if required. In this regard the carbon nanotube field effect transistor (CNTFET) will be the most promising alternatives for its unique properties. It was demonstrated long before in 1998 (Tans *et al*., 1998). Carbon nanotube field-effect transistors offer high mobility for ballistic transport, high mechanical and thermal stability with high resistance to electro migration, attracting strong interest as alternative high device technologies for the future nano electronics applications (Avouris *et al*., 2007). Recently, a carbon nanotube transistor, which integrates ultra-short channel, thin high-k top gate insulator and excellent Pd source-drain contact is demonstrated using a self-align technique (Javey *et al*., 2008).

This paper proposes CNTFET with ZrO_2 as gate oxide which is also one of the most promising devices. This paper has been devised into main two sections. In the first section, the mobility of CNTs has been discussed with analyzing the Density of State (DOS) of different types of nanotubes and in the second part, the proposed CNTFET device modeling has been described with its parameters, along with simulation results.

II. Carbon Nanotube

Carbon is an element with symbol C. Its atomic number is 6 ($1s^2 2s^2 2p^2$). Carbon is a group 14 element that resides above silicon on the periodic table. It is nonmetallic and tetravalent making four electrons available to form covalent chemical bonds. Carbon has four electrons in its valance shell like silicon ($1s^2 2s^2 2p^6 3s^2 3p^2$) and germanium ($1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^2$). There are several allotropes of carbon like graphite, diamond and amorphous carbon (Carbon materials

Auhtor α σ ρ: Electrical and Electronic Engineering, American International University-Bangladesh, Dhaka, Bangladesh.
e-mail: faisal274550@gmail.com

© 2017 Global Journals Inc. (US)

research group, University of Kentucky). When carbon atoms are arranged in crystalline structures composed of benzene like rings, they form several allotropes that contain totally exceptional electronic properties.

The physical properties of carbon vary widely with the allotropic form (List of thermal conductivities, Wikipedia). Diamond, carbon nanotubes and graphene have the highest thermal conductivity of all known materials (e.g., diamond: 900-2300 $Wm^{-1}K^{-1}$, carbon nanotube: 3180-3500 $Wm^{-1}K^{-1}$) (Faisal and Ali, 2015) under normal conditions.

Carbon Nanotubes (CNTs) are an allotrope of carbon. Carbon nanotubes have many forms, differing in length, thickness and in the type of helicity and number of layers. It can be categorized into Single Walled Carbon Nanotube (SWCNT) and Multi Walled Carbon Nanotube (MWCNT) shown in Fig. 1 and 2. The carbon nanotubes have diameters from less than 1nm to 50 nm. These possess excellent mechanical and transport properties too.

The rolled graphene (CNT) can be explained by a coordinate of indices (n, m), which is known as Chiral Vector. It represents whether CNT is metallic or semiconducting and diameter of CNT. The table shown below describes "Chirality of carbon nanotube. The diameter of carbon nanotube is given by:

$$d = \frac{\sqrt{3}a_{c\text{-}c}}{\pi}\sqrt{m^2 + mn + n^2} \quad (1)$$

Where:

$a_{c\text{-}c}$ = 0.142 nm is the carbon-carbon bond length

Figure 3 and 4 shows the Density of State (DOS) of different types of nanotubes. The simulated end states are within the energy gap of semiconducting carbon nanotubes, implying that the end states are a 1-D analogy with conventional surface states. Since the band gaps of carbon nanotubes are small, CNTs are either metallic or semi conductive. The energy band structures of carbon atom provide an occupied energy level in the band gap depending upon the density of states and types of CNT. The (10, 0) nanotube acts as semi conducting material since it has energy gap between conduction and valence band whereas the (8, 8) nanotube acts as conducting material as the valance and conduction bands are overlapping.

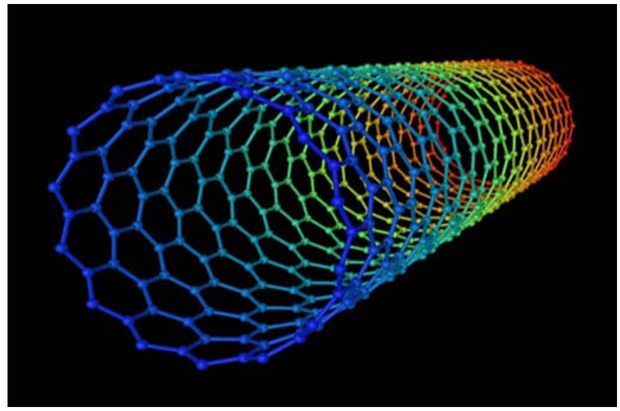


Fig. 1: Single walled carbon nanotube

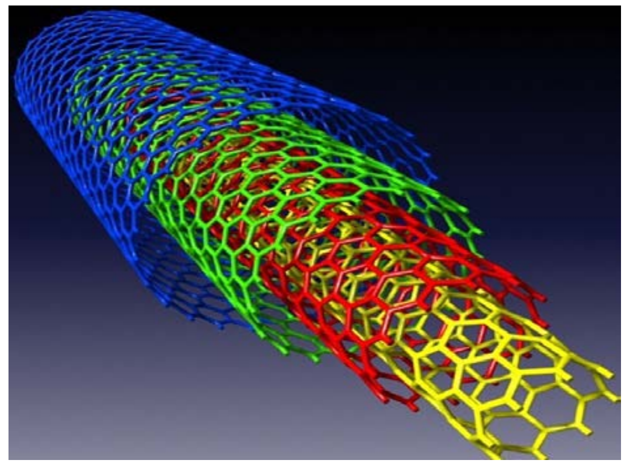


Fig. 2: Multi walled carbon nanotube

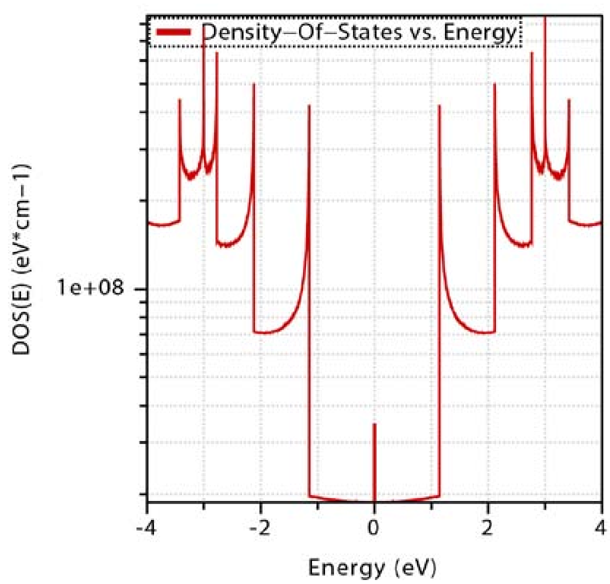


Fig. 3: DOS vs. Energy for (8, 8)

© 2017 Global Journals Inc. (US)

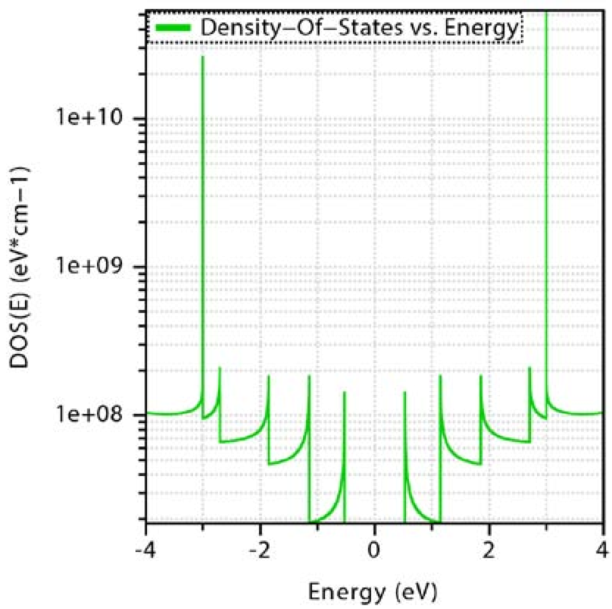


Fig. 4: DOS vs. Energy for (10, 0)

III. Carbon Nanotube Field Effect Transistor

A Carbon Nanotube Field-Effect Transistor (CNTFET) indicates a field-effect transistor which handles a single carbon nanotube or an array of carbon nanotubes as the channel material rather silicon in the conventional MOSFET structure. CNTFET is a three-terminal (three to six layers) device consisting of a semiconducting nanotube bringing two contacts (source and drain) and act as a carrier channel which is turned on or off electrically via the third contact (gate). According to the fabrication geometry there are many type of CNTFET devices such as Back-gated CNTFET, Top- gated CNTFET, Wrap-around gate CNTFET, Suspended CNTFET etc. (Wind *et al*., 2002; Chen *et al*., 2008; Farmer and Gordan, 2006; Cao *et al*., 2005). These are divided broadly in two categories: Planner CNTFET and Coaxial CNTFET which are shown in Fig. 5. CNTFETs show different characteristics compared to MOSFETs in their theoretical experiments. In a planar gate structure, the p-CNTFET produces ~1500 A/m of the on-current per unit width at a gate overdrive of 0.6 V while p-MOSFET produces ~500 A/m at the same gate voltage (Cao *et al*., 2005). This on-current advantage contains from the high gate capacitance and modified channel transport. Since an effective gate capacitance per unit width of CNTFET is about double that of p-MOSFET, the compatibility with high gate dielectrics becomes a superior advantage for CNTFETs (Sahoo and Mishra, 2009).

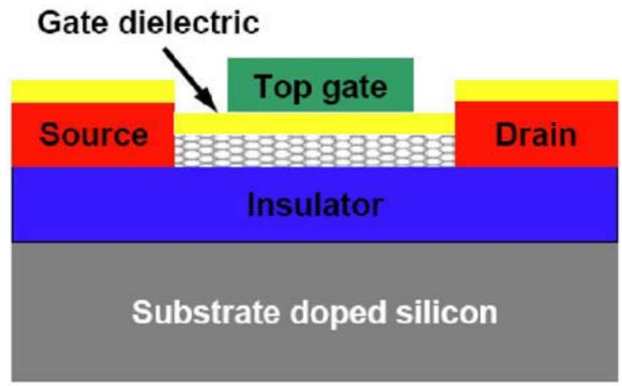


Fig. 5: Planner CNTFET

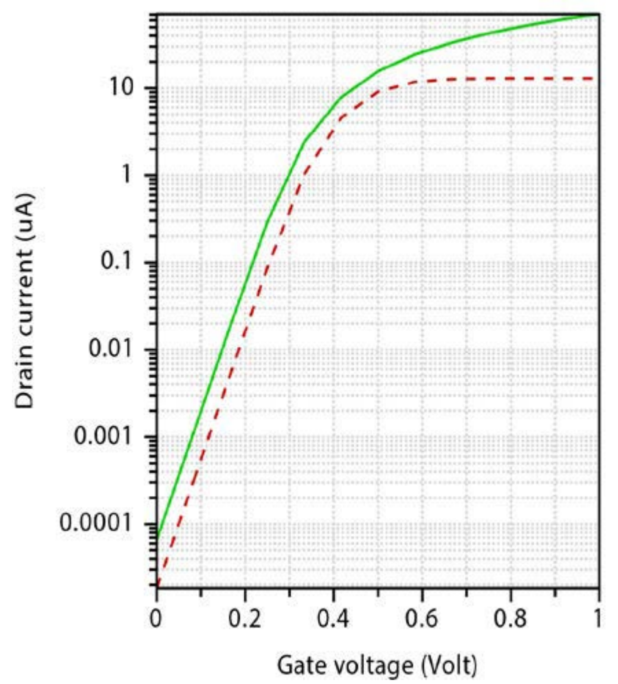


Fig. 6: I-V characteristics of proposed CNTFET (Solid line)

IV. Modelling of CNTFET

The proposed device is formed with a (10, 0) CNT. So the channel diameter =0.782885nm. For gate insulation ZrO_2 (k = 25) is used. Energy gap for a nanotube is given by:

$$Eg = \frac{2a\gamma_{c\text{-}c}}{channel\ diameter} \quad (2)$$

Where:

γ = The nearest neighbor-hopping parameter (γ = 2.5-3.2)

Using γ = 3, the energy gap is 1.0882eV. The parameters used in proposed model and calculations are given in Table 3.

© 2017 Global Journals Inc. (US)

Table 1: Properties of carbon nanotube

Material	Young's modulus (GPa)	Tensile strength (GPa)	Electrical conductivity (mho/m)
Single wall nanotube	~1050	150.000	$\sim 10^{7}$
Multi wall nanotube	~1200	150.000	$\sim 10^{6}$
Steel	208	0.400	$\sim 10^{5}$
Wood	16	0.008	$\sim 10^{-4}$

Table 2: CNT classifications

Type of CNTs	Values of m and n	State
Armchair	m=n	Metallic
Zigzag	m=0	Semiconducting
Semiconducting or Chiral	n-m≠3×integer	Semiconducting (large bandgap)
Quasi-Semiconducting	n-m=3×integer	Semiconducting (small bandgap)

Table 3: Proposed parameters

Energy gap	1.0882 eV	Gate oxide thickness	1.6 nm
CNT diameter	0.78 nm	Gate dielectric (ZrO2)	25

Conductance between two leads source and drain is defined in terms of current and voltage: I = GV. Using Landauer formula (Nazarov and Blanter, 2009), conductance is expressed by the following equations:

$$G = \frac{2Te^2}{h} \tag{3}$$

where, q is the charge of electron and h is the Planck's constant. T is known as the transmission function in terms of energy that represents the probability of an electron injected at one end of a conductor will emit at the other end. T can be expressed as:

$$T = trace\left[\Gamma_S G_0^r \Gamma_D G_0^a\right] \tag{4}$$

G_0^r G_0^a represents the retarded and advanced Green's function of the nanotube and Γ_D, Γ_S are the coupling of the CNT to the source and the drain. The retarded Green's function is calculated by:

$$G_0^r = \left(EI - H - \Sigma_S \ \Sigma_D\right)^{-1} \tag{5}$$

where, E is Fermi energy, I is the identity matrix, H is the Hamiltonian of the nanotube. ΣS, ΣD is the self-energy terms at the source and drain coupling of the contacts are the calculated using the broadening function of the self-energy terms at the source and drain.

The nanotube behaves as the conducting channel in the CNTFET from the source to drain; it depends on the current density of the tube. The current density is a measure of the density of flow of an electric current per unit area across a section. The current density is an area density described by J. The current through an area A is simply the flux of the current density through that area as shown below:

$$I = \int J.dA \tag{6}$$

Using the charge density within the device, the NEGF transport equation is solved teratively with the posison equation until self-consistant potential distribution is found. Finally the current is calculated using the Landauer Böuttiker expression:

$$I_d = \frac{4d\int T(E)\left[f_s(E) - f_d(E)\right]dE}{h} \tag{7}$$

T is the transmission probability across the source/drain; f_S and f_D are the source/drain Fermi-Dirac distribution functions consistent potential; The equation is solved simultaneously to evaluate and characterize the performance of these devices.

V. Simulations

Hafnia (HfO_2) adopts the same structure as zirconia (ZrO_2, K=~25). Unlike TiO_2 (k = 40), which features six-coordinate Titanium in all phases, zirconia and HfO_2 consists of seven- coordinate metal centers (Miikkulainen *et al.*, 2013; Faisal and Ali, 2012). Hafnium-based oxides were introduced by Intel in 2007 as a replacement for silicon oxide as a gate insulator in field-effect transistors (Source: INTEL). We simulate the I-V Characteristics of CNTFET using ZrO_2 as gate insulator for proposed model. The high-K gate insulator and bigger CNT diameter allows higher drain current.

Figure 7 shows the output characteristics of the proposed CNTFET. The channel allows the current to flow when the gate voltage is greater than 0.3 V. So the on current is 70 μA at Vg = 2.0 V and Vd = 1.0 V and the off current is 6.61e-05 μA at Vg = 0V and Vd = 1.0 V.

Global Journal of Researches in Engineering (F) Volume XVII Issue II Version I Year 2017

© 2017 Global Journals Inc. (US)

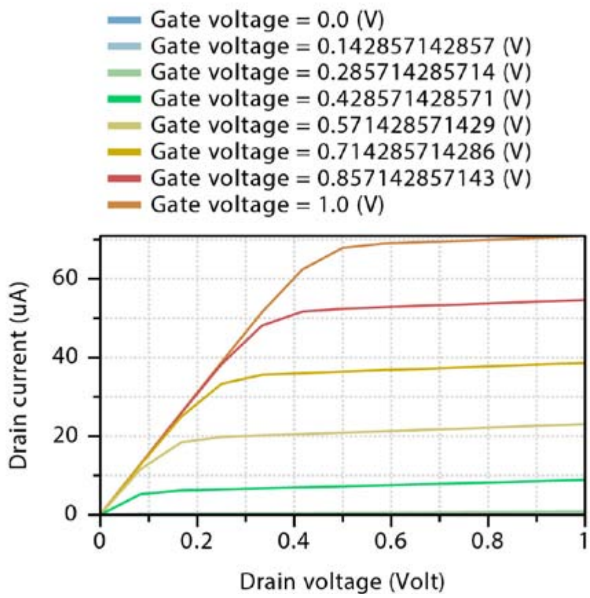


Fig. 7: Id vs. Vd (Output characteristics) curve at different Vg

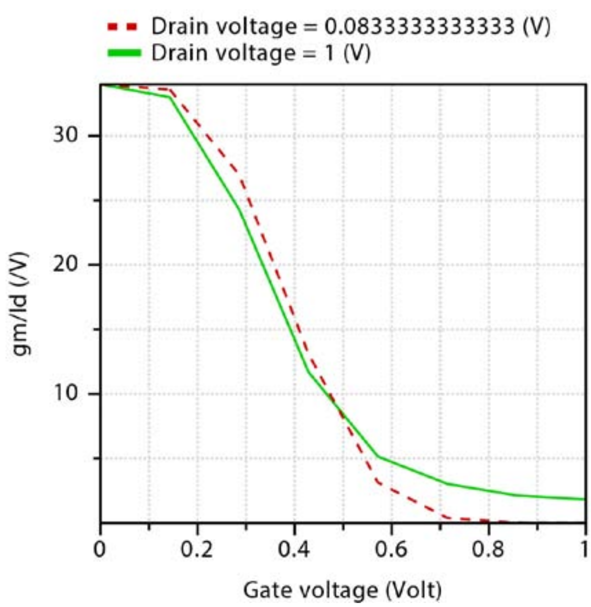


Fig. 8: Transconductance of CNTFET

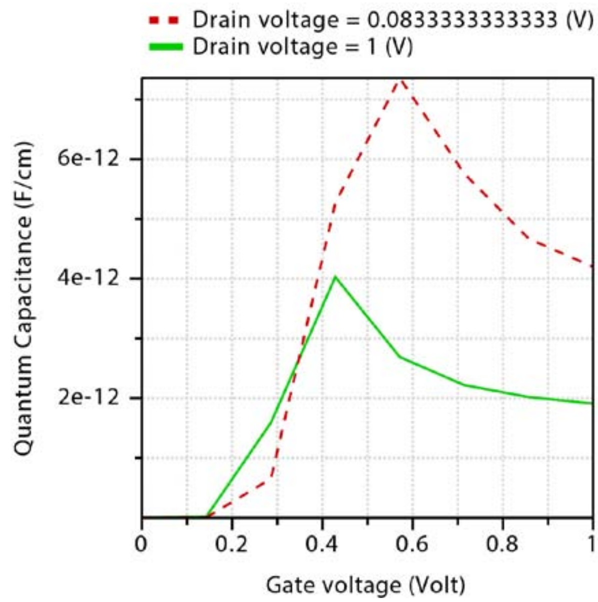


Fig. 9: Quantum capacitance vs. Gate voltage

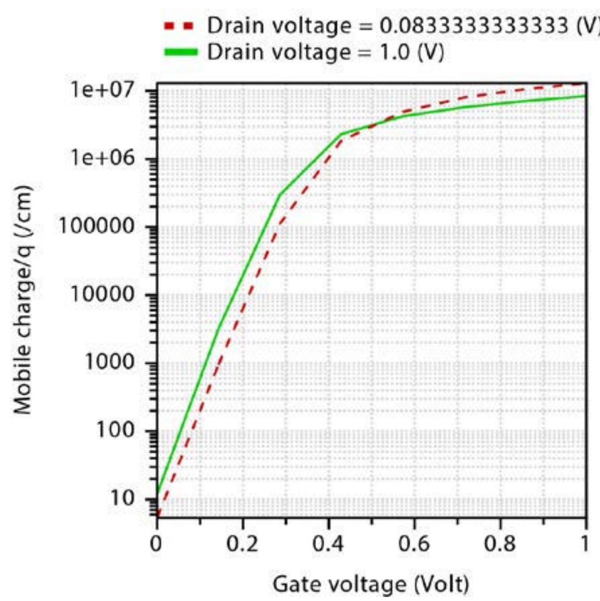


Fig. 10: Mobile charge behavior at gate voltage

In order to achieve a relatively large transconductance the CNT must have large channel diameter. The larger the transconductance, the greater the gain it will deliver. As the diameter gets smaller this reduces the carrier mobility, changing the transconductance. The transconductance behavior is obtained at 0.78 nm diameter, with different drain voltage (Fig. 8). The transconductance varies by a factor of 10/V depending on the amount of voltage applied to the gate. However, the increase of VG will reduce the allowed voltage signal through the drain.

Quantum capacitance is associated with the properties of channel material. As the density of state is finite in a semiconductor quantum well, the Fermi level needs to move up above the conduction band edge as the charge in the quantum well increases. This movement of Fermi level requires energy and this conceptually corresponds to quantum capacitance. Figure 9 shows the quantum capacitance versus the gate voltage at different drain voltages. It is clear that a higher quantum capacitance can be found at a gate voltage 0.42 or 0.57 volt (for proposed model).

© 2017 Global Journals Inc. (US)

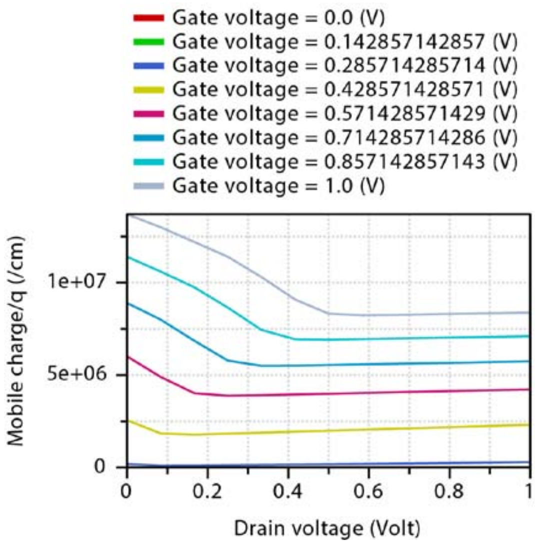


Fig. 11: Mobile charge behavior at drain voltage

As insulator thickness approaches the nanometer range, the insulator capacitance becomes comparable to the inversion layer capacitance, which means that the QC and the centroid capacitance start to affect the gate capacitance.

Figure 10 shows the mobile charge behavior as a function of gate voltage. It is noticed that increasing the drain voltage beyond a specific value has no longer an effect on the shape of the curves since the mobile charge remains constant. It is also observed that low drain voltage produces higher mobile charge and high drain voltage produces lower mobile charge. Also, it has been noticed that the mobile charge increases with the reduction in gate insulator thickness. Figure 11 shows the mobile charge behavior as a function of drain voltage.

VI. Conclusion

The proposed parameters and gate dielectric of CNTFET make the transistor a challenge to develop and control the aspects of it such maximum transconductance. We found two regions for maximum transconductance. Zirconia is used in optical coatings and in DRAM capacitors as a high- k dielectric and in advanced metal-oxide semiconductor devices. The advantage for proposed CNTFET is its high dielectric constant: The dielectric constant of ZrO_2 is 4-6 times higher than that of SiO_2. In recent years, zirconium oxide (as well as doped and oxygen-deficient zirconium oxide) attracts additional interest as a possible candidate for resistive-switching memories (Lin, 2011).

VII. Acknowledgement

The authors' would like to thank Dr. M. Tanseer Ali for his remarks and invaluable advises on different aspects of this work.

Funding Information

The authors have no support or funding to report.

Ethics

The authors' hereby declare, this work is their own contribution and hence there would not be any ethical issues related to this manuscript.

References Références Referencias

1. Avouris, P., Z. Chen and V. Perebeinos, 2007. Carbon-based electronics. Nature Nanotechnol., 2: 605-615. DOI: 10.1038/nnano.2007.300
2. Cao, J. Q. Wang and H. Dai, 2005. Electron transport in very clean, as-grown suspended carbon nanotubes. Nature Mater., 4: 745-749. DOI: 10.1038/nmat1478
3. Chen, Z., D. Farmer, S. Xu, R. Gordon and P. Avouris, 2008. Externally assembled gate-all-around carbon nanotube field-effect transistor. IEEE Electron Device Lett., 29: 183-183. DOI: 10.1109/LED.2007.914069
4. CMRG, 0000. Carbon Materials Research Group. History of Carbon, University of Kentucky.
5. Faisal, A.M. and T. Ali, 2015. Simulations of enhanced CNTFET with HfO_2 gate dielectric. Int. J. Sci. Res. Public., 5: 652-657.
6. Farmer, D.B. and R.G. Gordon, 2006. Atomic layer deposition on suspended single-walled carbon nanotubes via gas-phase noncovalent functionalization. Nano Lett., 6: 699-703. DOI: 10.1021/nl052453d
7. Hamada, N., S.I. Sawada and A. Oshiyama, 1992. New one-dimensional conductors: Graphitic microtubules. Phys. Rev. Lett., 68: 1579-1579. DOI: 10.1103/PhysRevLett.68.1579
8. Heinze, S., J. Tersoff, R. Martel and V. Derycke, 2002. Carbon nanotubes as schottky barrier transistors. Phy. Rev. Lett., 89: 106801-106801. DOI: 10.1103/PhysRevLett.89.106801
9. Iijima, S., 1991. Helical microtubules of graphitic carbon. Nature, 354: 56-58. DOI: 10.1038/354056a0
10. ITRS, 2003. International Technology Roadmap for Semiconductors. 1st Edn., ITRS, Austin, pp: 646.
11. Javey, A., J. Guo, Q. Wang, M. Lundstrom and H.J. Dai, 2003. Ballistic carbon nanotube field-effect transistors. Nature, 424: 654-657. DOI: 10.1038/nature01797
12. Lin, K.L., 2011. Electrode dependence of filament formation in HfO_2 resistive-switching memory. J. Applied Phys., 109: 084104-084104. DOI: 10.1063/-1.3567915 List of thermal conductivities.
13. Miikkulainen, V., M. Leskelä, M. Ritala and R.L. Puurunen, 2013. Crystallinity of inorganic films grown by atomic layer deposition: Overview and general trends. J. Applied Phys., 113: 021301-021301. DOI: 10.1063/1.4757907

© 2017 Global Journals Inc. (US)

14. Mintmire, J.W., B.I. Dunlap and C.T. White, 1992. Are fullerene tubules metallic. Phys. Rev. Lett., 68: 631-631. DOI: 10.1103/PhysRevLett.68.631
15. Nazarov, Y.V. and Y.M. Blanter, 2009. Quantum transport: Introduction to Nanoscience. 1st Edn., Cambridge University Press, Cambridge, ISBN-10: 0521832462, pp: 581.
16. Sahoo, R. and R.R. Mishra, 2009. Simulation of carbon nanotube field effect transistors. Int. J. Electronic Eng. Res., 1: 117-125.
17. Saito, R., G. Dresselhaus and M.S. Dresselhau, 1998. Physical Properties of Carbon Nanotubes. 2nd Edn., Imperial College Press, London, ISBN-10: 1860940935, pp: 259.
18. Saito, R., M. Fujita, G. Dresselhaus and M.S. Dresselhaus, 1992. Electronic structure of chiral graphene tubules. Applied Phys. Lett., 60: 2204-2204. DOI: 10.1063/1.107080
19. Tans, S.J., A.R.M. Verschueren and C. Dekker, 1998. Room-temperature transistor based on a single carbon nanotube. Nature, 393: 49-52. DOI: 10.1038/29954
20. Wind, S.J., J. Appenzeller, R. Martel, V. Derycke and P. Avouris, 2002. Vertical scaling of carbon nanotube field-effect transistors using top gate electrodes. Applied Phys. Lett., 80: 3817-3817. DOI: 10.1063/1.1480877

© 2017 Global Journals Inc. (US)

Global Journals Inc. (US) Guidelines Handbook 2017

www.GlobalJournals.org

Fellows

FELLOW OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (FARSE)

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

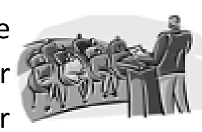
- The "FARSE" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSE or William Walldroff, M.S., FARSE.

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

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

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

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

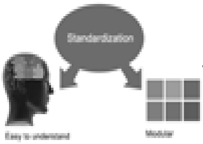


You may join as member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. In addition, it is also desirable that you should organize seminar/symposium/conference at least once.

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

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

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



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

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

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

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

© Copyright by Global Journals Inc.(US)| Guidelines Handbook

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.

© Copyright by Global Journals Inc.(US)| Guidelines Handbook

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).

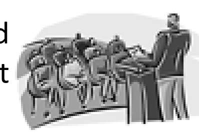
The “FARSC” is a dignified title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

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.



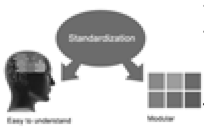
The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

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.

© Copyright by Global Journals Inc.(US) | Guidelines Handbook

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



After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.

The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

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

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

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

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

Other:

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

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

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

Note :

"

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

"

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.

© Copyright by Global Journals Inc.(US)| Guidelines Handbook

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.

© Copyright by Global Journals Inc.(US)| Guidelines Handbook

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.

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

Index

save our planet

Global Journal of Researches in Engineering

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

ISSN 9755861

© Global Journals