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

Global Journal of Researches in Engineering: F

Electrical and Electronic Engineering

System Efficiency Enhancement

Grid-Connected DFIG-Driven WECS

Highlights

Designing a Monitoring Device

Design for Load Frequency Control

Discovering Thoughts, Inventing Future

VOLUME 22 ISSUE 2 VERSION 1.0

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

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

Volume 22 Issue 2 (Ver. 1.0)

Open Association of Research Society

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

Global Journals Inc.

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

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

Publisher's Headquarters office

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

Offset Typesetting

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

Packaging & Continental Dispatching

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

Find a correspondence nodal officer near you

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

eContacts

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

Pricing (Excluding Air Parcel Charges):

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

Editorial Board

Global Journal of Research in Engineering

Contents of the Issue

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 22 Issue 2 Version 1.0 Year 2022
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Flexible Boundary Multi-Microgrids Power Distribution Systems with Internet of Thing for System Efficiency Enhancement

By Md Shahin Alam & Seyed Ali Arefifar
Oakland University

Abstract- Multi-microgrid power distribution systems are gaining attention in the smart grid era. Distributed energy resources, energy storage, as well as energy sharing and scheduling has a great potential to enhance multi-microgrid systems' performance. This research develops an algorithm for optimal operation of various distributed energy resources in a flexible boundary multi-microgrid power distribution network, considering internet of things (IoT). The proposed algorithm used in this research can reduce power system operating costs, power, and energy losses and emissions, and ultimately increase the systems' efficiency. A hybrid Particle Swarm Optimization-Tabu Search algorithm is developed for optimization purposes.

Keywords: microgrid; distributed energy resources, distribution system; energy storage system; IoT; optimization.

GJRE-F Classification: DDC Code: 004.678 LCC Code: QA76.9.B45

FLEXIBLEBOUNDARYMULTI-MICROGRIDSPOWERDISTRIBUTIONSYSTEMSWITHINTERNETOFTHINGFORSYSTEMEFFICIENCYENHANCEMENT

Strictly as per the compliance and regulations of:

Flexible Boundary Multi-Microgrids Power Distribution Systems with Internet of Thing for System Efficiency Enhancement

Md Shahin Alam [α] & Seyed Ali Arefifar [σ]

Abstract- Multi-microgrid power distribution systems are gaining attention in the smart grid era. Distributed energy resources, energy storage, as well as energy sharing and scheduling has a great potential to enhance multi-microgrid systems' performance. This research develops an algorithm for optimal operation of various distributed energy resources in a flexible boundary multi-microgrid power distribution network, considering internet of things (IoT). The proposed algorithm used in this research can reduce power system operating costs, power, and energy losses and emissions, and ultimately increase the systems' efficiency. A hybrid Particle Swarm Optimization-Tabu Search algorithm is developed for optimization purposes. This algorithm is then applied to the well-known Pacific Gas and Electric Company 69-bus power distribution network for simulations and case studies to show the impacts of various energy resources, the internet of things, and flexible boundary conditions of multi-microgrid on systems' performance indices. The probabilistic uncertainty states of photovoltaics and wind turbines are considered to get more accurate results. The simulation results presented in the paper shows great benefits are achievable through operating the system as multi-microgrid and by energy sharing between microgrids, especially with consideration of the flexible boundary conditions and internet of things. The results obtained from the simulations confirm significant increase in the system efficiency and systems' performance indices, including operational costs, power losses and environmental emissions.

Keywords: microgrid; distributed energy resources, distribution system; energy storage system; IoT; optimization.

I. Introduction

Distributed generators are gaining popularity in the power system industry as they are helping to modernize the traditional energy network. Distributed generators are classified as dispatchable units like a gas turbine and non-dispatchable units like PV solar and wind turbine, located near the consumer's site to enhance distribution systems performance.

Technological innovation in energy systems like the Internet of Things (IoT) is at the forefront of this modernization for the real-time monitoring, situational awareness and intelligence, and control of such resources. In this scenario, a group of interconnected distributed generators and loads can create microgrids with unified characteristics [1]. Microgrids improve overall power system efficiency as they enhance the system reliability, resiliency, power quality, power losses, and operational costs [2]. Energy management strategies using real-time monitoring and control with IoT technology depend on the type of DERs, load requirements, and the expected operational scenarios [3]. Since there are uncertainties in the renewable-based DGs, it is challenging for the power system operators to balance the load and generators inside the microgrid, especially if it disconnects from the grid as island during an extreme event. Therefore, while there is excess energy with one microgrid and a deficit in the other, it would be beneficial for those to share their excess to supply remaining loads. This energy sharing strategy between MGs in a multi-MG power distribution system significantly enhances the system performance and efficiency when compared to a single MG [4].

Energy sharing and scheduling between different DGs in multi-MGs is the crucial step for enhancing overall system performance. Distributed energy generation's location and their corresponding generation capacities based on hourly load demand, helps to reduce system losses and improve system efficiency. If there is any time delay between load demand signal and generation adjustment process, the system reliability and efficiency would be affected. Introduction of IoT technology in power systems facilitates the real-time monitoring and control of load and generation. IoT in multi-MGs supports DGs and loads in maintaining generation-consumption balance and implement intelligent energy management strategies in real time to enhance system efficiency.

Different types of distributed generators and their corresponding scheduling are addressed in the literature for the optimal operation of MGs using IoT. For instance, the authors in [5] proposed a model for a virtual microgrid that divides a distribution system as a set of sub-grids, making the autonomous grid more resilient. Reference [6] uses the IoT technology for microgrid controls and remote monitoring purposes. The authors in [7] apply the IoT to make real-time communication among DGs in MGs considering energy management for tertiary controlling purposes. The

Author α: Energy & Technology Department at Odessa College, Odessa TX, USA. e-mail: mdsalam@odessa.edu
Author σ: ECE Department at Oakland University, Rochester MI, USA. e-mail: arefifar@ieee.org

authors in reference [8] propose scheduling plans for the existing distributed generators located in MGs for its economic and stable operation. The objective of their research is to minimize the microgrid operational costs, especially during the islanded mode, having no power from the primary grid and making the MG more stable. A retroactive regime-based energy scheduling applicable in small-scale MGs, is proposed in [9], where the practical implementation does not need much information for the uncertain generation's capabilities. The authors in [10] propose a two-stage stochastic mixed-integer programming method for optimal distributed generators operations while considering their best locations in the microgrids during the microgrid operation. This research aimed to operate the distributed generators in such a way that help to run the microgrid with lower operating costs and make the microgrid system more resilient. The authors in [11] propose a PSO-based optimization methodology by considering the DGs locations and corresponding capacities based on the profile of load demand in the microgrid system. This research aimed to minimize the microgrid energy loss for a given period by considering the DGs and load uncertainties. The authors in [12] present an energy management strategy in a campus microgrid for controlling the dis-tributed generators included in that MG. The objective of this research is to minimize the system operating costs and maximize renewable integration. A novel distributed event-based energy management strategy is proposed in [13] by optimally scheduling distributed generators to balance load generation while minimizing the total system costs. Note that the literature review here considers optimal scheduling of single MG. More system benefits are possible by considering the energy sharing between multiple MGs, which help the overall system to be more reliable, resilient, and efficient.

In [14], a game theoretic-based distributed coordination control strategy is pro-posed, which ensures the self-benefit of each MG during the global benefit for the multi-MG. In [15], a multi-MG operation uses a co-optimization model by energy sharing between existing MGs. This model proposes a lower pricing cost and maintains good computational efficiency. A local market-based energy sharing model between multiple MG is developed in [16] to minimize the operational costs for each MG and among MGs. In this model, optimal scheduling of DG within MG is done using the market clearing process. A cooperative game-based optimization model proposes a joint operation between a distribution network and rural multi-MG is proposed in [17]. The objective of this joint operation between the distribution network and multi-MG is to maximize the benefit of each MG and improve the distribution network efficiency and reduce the overall system operational costs. More research is performed in the literature in the context of multi-MG to improve system overall performance [18]-[19]. Furthermore, the authors in reference [20] propose a dynamic microgrid by considering a flexible boundary among MGs based on the allocation and coordination of agents to achieve boundary mobility. This flexibility of boundaries may affect the overall system management between multi-MG operations. In [21], the authors develop a mixed-integer linear programming-based operational framework model to provide reliable service restoration using the advantages of flexible DGs within MGs. The authors in [22] propose a model to form a flexible MG condition to improve the overall system reliability using a demand response program.

Literature review shows that much research is conducted on DGs controls and operations, energy sharing using IoT and energy management in microgrid and multi-MGs. Nevertheless, further investigation is needed for IoT and energy management applications on multi-MGs, especially in the perspective of flexible boundary conditions. Multi-MG operation within the distribution system without any time delays is required to have a more efficient energy system that will ensure real-time feedback between generations and load. IoT is utilizing the concept of such advanced techno-logical opportunities. This research expands the IoT applications' impact with energy management on improving microgrids' performance. Dispatchable gas turbines, non-dispatchable PV and wind turbines, and energy storage within multi-MGs as dis-tributed energy resources are considered in the research. The Pacific Gas and Electric Company (PG&E) 69-bus power distribution system is selected, and the energy re-sources' optimal locations and capacities are found using a relatively new hybrid PSO-TS optimization method to increase the overall system efficiency considering flexible boundary conditions within MGs. The developed model promotes the in-vestment in the optimal generation facilities among profit-oriented entities for utilities or system operators and the consumers. Energy management strategy considering IoT is applied for the scheduling of energy resources without any time delay of energy generation and load forecasting. Thus, the main contribution of this paper is summarized as follows:

1) Develop a model for finding optimal operation of distributed energy resources in terms of their locations and capacities, considering flexible boundary conditions within multi-MGs to improve the overall system performance.
2) Formulate the algorithm of distributed energy resources planning and operation while considering no time delay between generation and loads using IoT inside multi-MGs.
3) Apply energy management to get maximum IoT support for rescheduling DGs operations for a flexible multi-MG boundary to improve the multi-MGs system's efficiency.

4) Present case studies for different capacities of energy resources with uncertain parameters within flexible boundary multi-MGs systems with and without IoT.

The rest of the paper is organized as follows. Section 2 describes the energy management and IoT in power distribution network. Section 3 describes the system modelling for both dispatchable and non-dispatchable generators as well as loads. Problem formulation and optimizing solution algorithm is presented in section 4 and section 5 respectively. Multi-MGs power distribution system are analyzed in section 6 where the results and simulation of this paper is presented in section 7. Impact of IoT in multi-MG is discussed in section 8 and finally conclusion of this paper is presented in section 9.

II. Energy Management and IOT in Power System

In multi-MG, the optimal scheduling of distributed energy resources is necessary to improve the system's performance. This scheduling of energy resources is a challenging task, especially in an uncertain load and generation scenario. It would be even more challenging in the case of multi-MG DGs scheduling and operation. Therefore, energy management is necessary in multi-MGs to ensure a proper balance between energy generation and load. Since there is usually more potential for power generation in a plan at certain times than power consumption, there is more than one option for reaching such balance. Since solar PV, wind turbines, and load used in this research have uncertainty in nature, considering states for these uncertainties is important for proper energy flow. Thus, controlling the DGs and getting power for delivering at the loads at a particular time can significantly impact the multi-MG operations and performance. Due to such significant impacts of DGs scheduling in multi-MGs operations, considering the energy management strategies is a crucial need for the microgrids de-signers and operators.

IoT in power networks provide a sustainable solution to enhance the multi-MG operation. In this research, IoT and energy management aim to utilize distributed energy resources for their optimal operation in real-time to minimize system operating costs and reduce carbon emissions while enhancing the overall system efficiency. Multi-MGs are present in this research to optimize power flow so that maximum power is obtained from the MGs with excess capacity and minimum power is obtained from the primary grid if there is availability. The target is to reduce energy dependency from the primary grid toward MGs, especially by energy management for DGs operations. In this case, flexibility in microgrid boundaries facilitates achieving this goal of improving the system's overall efficiency. The power exchanges to-and-from the multi-MGs are done in real-time with real-time rates using IoT. With IoT, the multi-MG system will become more efficient, cost-effective, and less pollutive especially considering flexible boundaries. IoT in a multi-MG system network provides real-time feed-back to the multi-MG and utility operators, which better serves customers through controlling functionalities [23]. The application of IoT and energy management help to improve system's performance, which is shown in detail in Section 7.

III. System Modeling

In this research, multiple microgrids are considered inside a distribution system. There are gas turbines, PV solar, wind turbines, and energy storage located in each MG. All microgrids are connected and can exchange power while needed. These multiple MG operations form multi-MGs, and energy can share within this multi-MG. All microgrids are also associated with the primary grid and can transfer power with the main grid. This section discusses the modeling for gas turbines, PVs, wind turbines, and energy storage in detail.

a) Distributed Generators

This research uses gas turbines as dispatchable distributed generators and active power sources, ensuring continuous energy if the fuel is available. Because of these dispatchable characteristics are the active power source that can provide specific power for the operators. Because of sustained power availability, the operational costs from this dispatchable generator measure per kWh. The difference between renewables-based DGs with the gas turbine is that it creates environmental emissions due to its natural gas fuel consumption.

The model for the gas turbine can be represented as [23].

$$C_0^{MT}\left(P_{MT}^{(t)}\right) = \frac{C_{ng}}{K}\sum\frac{P_{MT}^{(t)}\times\Delta t}{\eta_{MT}} \tag{1}$$

Here C_{ng} is the price for natural gas, K is a co-efficient, and η_{MT} represents the efficiency.

Be noted that the initial investment costs of each dispatchable distributed generator have been ignored in this research since it won't affect the goals of energy management as an operational issue. The energy sharing between dispatchable and non-dispatchable generators happens within the multi-MGs by considering tertiary controls of these DGs and optimizing operational goals.

Moreover, this research uses wind turbines and PV solar as the non-dispatchable distributed generators for the multi-MGs application. Wind turbines and PVs are clean sources of energy, which are comparatively cheap and environmentally friendly. The problem with these types of distributed generators is that they are uncertain. Since these distributed generators show non-dispatchable characteristics, their output power is indefinite for different times of 24 hours. The uncertain ability of the wind turbine is mainly the wind speed and features of the wind turbine module itself while delivering its output power. Moreover, PV's output power also depends on the outside whether like sunshine, temperature, and the PV module itself. In this case, it is essential to model these distributed generators with their uncertain behavior.

In this research, the wind speed of wind turbines is modeled hourly by the Weibull PDF using historical data [24].

$$Pv_w(v_{aw}) = \begin{cases} 0 & 0 \le v_{aw} \le v_{ci} \\ P_{rated} \times \frac{v_{aw}-v_{ci}}{v_r-v_{ci}} & v_{ci} \le v_{aw} \le v_r \\ P_{rated} & v_r \le v_{aw} \le v_{co} \\ 0 & v_{co} \le v_{aw} \end{cases} \quad (2)$$

Where v_{ci} represents the wind's cut-in speed, v_r and v_{co} are the rated speed and cut-out speed of the wind, respectively. Pv_w and v_{aw} are the wind's output power and average wind speed for the state w.

For modeling PV, the solar irradiance of the PV module is modeled hourly for 24 hours by the Beta PDF using historical data [24].

$$f_b(s) = \frac{\tau(\alpha + B)}{\tau(\alpha)\tau(\beta)} \times s^{(\alpha-1)} \times (1-s)^{\beta-1}$$
$$0 \le s \le 1; \alpha, \beta \ge 0 \quad (3)$$

where s represents the solar irradiance, $f_b(s)$ is the beta distribution function and α and β are the corresponding Beta PDF function parameters that can be calculated by equation (4).

$$\alpha = \frac{\mu \times B}{1-\mu} \times s^{(\alpha-1)}$$
$$\beta = 1 - \mu \times \left(\frac{\mu \times (1+\mu)}{\sigma^2} - 1\right) \quad (4)$$

Energy storage is gaining popularity in power areas as it works as both load and generator and can operate in an economic way, considering charging and discharging functions. Energy storage can act as a dispatchable distributed generator since it can deliver continuous power if the charge is available. The optimal storage operation is influenced by the hourly availability of wind and solar PV power and price from the utilities and the optimization objectives. An energy management system using IoT schedules energy storage and other DGs operations in the multi-MGs. In parallel with other DGs in the design, ESS operations also happen to minimize the distribution system operational costs. The ESS maintained two satisfying constraints represented by equations (5) and (6) during the charging and discharging periods.

$$Charge: C(t+1) = C(t) + \Delta t P_t^{E,c} \eta_c \quad (5)$$

$$Discharge: C(t+1) = C(t) - \frac{\Delta t P_t^{E,d}}{\eta_d} \quad (6)$$

where $P_t^{E,c}$ represents the ESS power at time t, and $P_t^{E,d}$ represents power supply from the storages at time period t. The amount of stored energy for the ESS is presents by $C(t)$ in this equation with time t. η_c and η_d represents the charging efficiency and discharging efficiency, respectively.

b) Loads

The load data in this paper takes from the IEEE RTS [25]. In this model, the hourly peak load is a percentage of the daily peak load. Based on the load variation in 24 hours, the scheduling of different distributed generators obtains. This research considers the probabilistic nature of load in 24 hours to get a more accurate result.

IV. Problem Formulation

This section describes the problem formulation for the distributed energy resources optimal scheduling within multi-MG. Also, this section presents the energy management objective function using IoT for distributed energy resources operations which are minimizing the system losses and costs together. Moreover, the formulation is presented for multi-MG system operation considering flexible boundaries within MGs based on DGs contributions. Moreover, there are several constraints for solving the optimization problem discussed at the end of this section.

a) Distributed Energy Resources Energy Management Objective Function

The application of energy management is first to find the optimal locations of the distributed energy resources. Then, considering IoT in multi-MGs having no time delay, energy management schedules such distributed energy resources for 24 hours. Based on this scheduling of the resources, multi-MG power network operational performance is calculated. Since this research considers a flexible boundary based on energy exchanges between MGs, there is a possibility to improve the multi-MGs power network operational performance. The objective function for finding the optimal locations of these distributed energy resources to minimize the system losses and operating costs together and can be formulated as follows by equation (7):

$$MinimizeOF = \sum_{h=1}^{24} \sum_{i=1}^{N} P_{loss}{}^{i} + OC_b \quad (7)$$

In this research, PV solar and wind turbines work as non-dispatchable, having chances of uncertainty during their operation. Thus, this objective function needs modification, and uncertainty states will be in front. So, the first part of the equation (8) will be

$$P_{loss} = \sum_{n=1}^{N_{st}} P_{loss} \times \rho_n \times h_n \qquad (8)$$

Where N_{st} is the total number of uncertainty states used in the multi-MGs; ρ_n and h_n work for only dispatchable distributed generators and for dispatchable DGs and ρ_n and h_n will be equal to 1.

Thus, the final objective function for finding the optimal locations of these distributed energy resources can be present by equation (9).

$$MinimizeOF = \sum_{h=1}^{24} \sum_{n=1}^{N_{st}} P_{loss} \times \rho_n \times h_n + OC_b \qquad (9)$$

Where OC_b is the multi-MGs power network system operational costs, which is described in the next section in detail.

b) Multi-MGs System Performance Assessment

This section evaluates the multi-MG power distribution network's performance regarding total system operational costs, which combines operating costs, losses, and environmental emissions. Environmental emissions are basically from the dispatchable gas turbines used inside the MGs and from the utility. The total system operational cost depends on several factors such as generators used for power generation, contributions of non-dispatchable generators and their uncertainty parameter, real-time pricing from the utilities, etc. Thus, scheduling the energy resources located in multi-MGs and their energy sharing is a significant factor for minimizing system operating costs. Scheduling would be more beneficial by providing extra flexibility for the distributed energy resources due to the boundary condition. If the distributed energy resources can have flexibility, more management is necessary between microgrids and would be more challenging for the power system operator. Interestingly, due to technological advancement, the situation is improving nowadays. In this research, the operational performance of a multi-MG power distribution system assesses due to the optimal distributed energy resources operations and multi-MG flexible boundary consideration. If the multi-MGs power distribution system already has some installed generators, the operational cost can be calculated from (10) for 24 hours considering the operating costs of such DGs. As mentioned previously, the DGs considered in this research are both dispatchable and non-dispatchable types.

$$OC_b = \sum_{h=1}^{24} (P_{s_h} + P_{sl_h}) \times C_{spu_h} - \sum_{h=1}^{24} \sum_{j=1}^{N_{DG}} P_{DG_{j_h}} \times C_{DGpu_{j_h}} + \sum_{h=1}^{24} \sum_{j=1}^{N_{DG}} E_{DG,d\&nd} \qquad (10)$$

where P_{s_h} represents the total power generated at time h, $P_{s\_l\_h}$ represents the corresponding system losses at time h, and C_{spu_h} is power costs at time h. $P_{DG\_j\_h}$ and $C_{DGpu\_j\_h}$ are the base DGs power and energy for per unit at time h, and N_{DG} is the total number of base DGs. $E_{DG,d\&nd}$ is the generation from the dispatchable and non-dispatchable generators.

The operating cost (OC) of a multi-MG power distribution system is calculated by equation (10) for the energy storage charging period. Since this research considers energy storage as a supportive resource for renewable energy sources, the calculation would be different during the charging mode and discharging mode of the energy storage. Energy storage can charge as a load during cheap price hours obtained from real-time data for the utility, typically during the off-peak period of the day. On the other hand, it can integrate into the multi-MG operation while more energy is needed from the utility, and there is no transformable energy between the MGs. Be noted that this research did not consider the initial energy storage investment costs; instead, it weighed only operational costs, and this would not affect the energy management process during its optimal operations and energy sharing within multi-MGs.

$$OC = \sum_{h=1}^{24} (P_{s_h} + P_{sl_h}) \times C_{spu_h} - \sum_{h=1}^{24} \left(\sum_{j=1}^{N_{DG}} P_{DG_{j_h}} \times C_{DGpu_{j_h}} \right) + \sum_{h=1}^{24} \sum_{m=1}^{N_{ESS}} P_{ESS_h} \times C_{ESS_h} \qquad (11)$$

As explained, equation (12) calculates a multi-MG power systems network's operational cost (OC) for the energy storage dis-charging period.

$$OC = \sum_{h=1}^{24} (P_{s_h} + P_{sl_h}) \times C_{spu_h} - \sum_{h=1}^{24} \left(\sum_{j=1}^{N_{DG}} P_{DG\_j\_h} \times C_{DGpu\_j\_h} \right) - \sum_{h=1}^{24} \sum_{m=1}^{N_{ESS}} \eta P_{ESS_h} \times C_{ESS_h} \qquad (12)$$

Where P_{NESS_h} is the energy storage's real power in kW, C_{ESS_h} is the per unit costs for the m^{th} energy storages, N_{ESS} is the total number of energy storage reforms inside the microgrid in the power distribution system, and η is the discharging efficiency.

Global Journal of Researches in Engineering (F) Volume XXII Issue II Version I Year 2022

One of the main concerning issues for the utilities and dispatchable generator owners is emissions. Equation (13) calculates the emissions from those generators in a multi-MGs power system [24], [26]:

$$C_E = P \times \sum_{j=1}^{m} E_p^j \times S \tag{13}$$

Where E_p is the emission price in terms of $\$/kg$, and S is the emission coefficient in kg/kwh.

c) Optimization Constraints

In this research, several constraints have been considered for using the optimization algorithm for solving the optimization problem, summarized as follows [24]:

Power flow equations should be modified to consider the real and reactive power generated by the energy sources.

$$P_{Sub\ t} + \sum P_{DG\ t} - \sum P_{Load\ t} = \sum_{i=1}^{nbus} V_{t,i} \times V_{t,j} \times Y_{i,j} \times \cos(\theta_{i,j} + \delta_{i,j} - \delta_{t,i}) \forall_{i,t} \tag{14}$$

$$Q_{Sub\ t} + \sum Q_{DG\ t} - \sum Q_{Load\ t} = -\sum_{i=1}^{nbus} V_{t,i} \times V_{t,j} \times Y_{i,j} \times \sin(\theta_{i,j} + \delta_{i,j} - \delta_{t,i}) \forall_{i,t} \tag{15}$$

The power limit for distributed energy resources integrates into the power network should be maintained the following constraints.

$$DERs_{min} \leq \mathrm{DERs}_{t,i} \leq DERs_{max} \forall_{t,i} \neq 1 \tag{16}$$

The penetration level of different types of energy resources (ERs) such as gas turbines, wind turbines, and PV solar capacities are another constraint.

$$\sum_{i=1}^{n} P_{ERs\_i} = \%\, ERs_i of feeder capacity \tag{17}$$

Voltage limit at all the system buses and current limit at all the power line should be maintained.

$$V_{min} \leq V_{t,i} \leq V_{max} \forall_{t,i} \neq 1\ I_i \leq I_{max\ ,i} \forall_{t,i} \neq 1 \tag{18}$$

V. Optimizing Solution Algorithm

In this research, optimization has been done for optimal energy resources operations regarding their locations and capacities.

In this case, the aim was to reduce the multi-MG energy losses and operating costs. Particle Swarm Optimization and Tabu Search Methods are two well-known optimization algorithms with unique features. Combining the two methods as explained below would improve the overall efficiency of the optimization process. Generally, particle swarm optimization (PSO) and Tabu Search (TS) are popular optimization methods used by many researchers. For any big or complex problem, PSO can easily find the optimal best locations [23]. PSO typically starts with a simple concept by considering two parameters, position, and velocity, while searching the object. At the beginning of its search, the initial position is chosen randomly from the defined areas selected by the operators. At this stage, the velocity is considered as zero. After a while, when PSO offers the best initial local and global solution from the searching spaces, it changes the best position and velocity. When it reaches convergence, PSO will choose the best result, and no more best results will come even after further iterations. Interestingly, TS can find the solution from his neighboring areas and use various memory structures to make the solution more economical and practical. The advantage of these memories is that they can easily avoid the target already in the tabu list and continue the search within other spaces effectively using different memory structures. The problem with these two types of algorithms, along with most other metaheuristics, is that they cannot claim the global optimum solution for a large dimension complex problem [23]. Therefore, this research uses a comparatively new method, namely hybrid PSO-TS, by taking benefit of those two methods principles. The proposed method can work and offer perfect results even in large scale optimization problems.

In this hybrid PSO-TS method, PSO is responsible for finding the initial solution and sent to the TS. Depending on the multi-MG flexible boundary condition, PSO will decide whether size and location will be fixed or need relocation of distributed energy resources before dispatch to the TS. TS will search for optimal results using memory structures. If TS can offer the better results from its experience than PSO, that will be considered for the next steps and forward to the PSO. This collaboration process between PSO and TS will continue until this hybrid method ensures the particles' own best and global best among all the particles in the searching spaces. The detailed steps regarding the hybrid PSO-TS algorithm and its application for optimal distributed energy storage location and operation in multi-MGs power distribution are illustrated in Fig. 1. It should be noted that the Newton Raphson's (NR) load flow method is chosen for power flow calculations in the multi-MGs system.

Global Journal of Researches in Engineering (F) Volume XXII Issue II Version I Year 2022

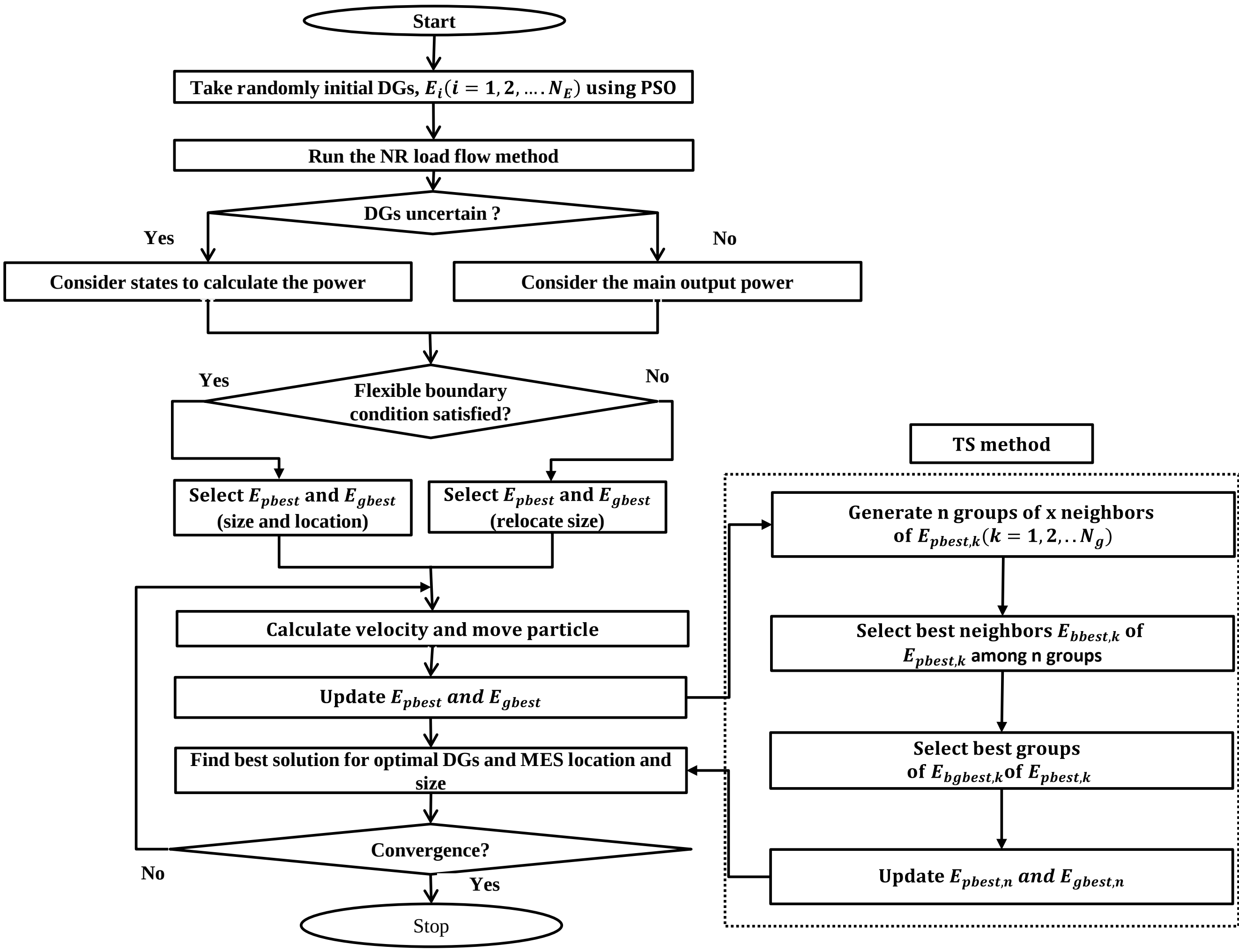


Figure 1: Flexible boundary condition-based hybrid PSO-TS solution algorithm

VI. Multi-MG Power Distribution System under Study

The well-known PG&E 69-bus power distribution system with five different microgrids is selected for simulations and case studies. The energy sharing from the distributed energy resources form multi-MGs for optimal operations of those energy resources. This research considers gas turbines, PVs, wind turbines, and energy storage systems inside microgrids to make the method practical. To create a sample multi-MG power distribution system, four arbitrary switches are allocated between the microgrids and the bus numbers 11-12, 15-16, 23-24, and 43-44. This four-switch positions make five microgrids. Further details on creating a multi-MG system in a power distribution grid can be found in [19]. The locations and capacities of each distributed energy resource are selected optimally based on minimizing multi-MG system losses and operating costs together. These locations are chosen for two different capacities of energy resources, 1125 kW and 2250 kW, shown in Table 1 and Table 2 in the results and discussion section. When the microgrids operate between themselves and share their energy based on energic economic, available generations, etc., it's called multi-microgrids. A flexible boundary condition will allow the distributed energy resources to share their energy more efficiently. The multi-MG power distribution system's standard operational costs can be calculated by using per kWh per unit for 24 hours. Similar 24-hour periods are considered for the calculations of system losses and system environmental emissions, and the data is taken based on reference [24]. Since there are uncertainties in the load generation states, because of renewables generators and load variations, in this research, their corresponding uncertain behaviors are also considered to get faster, accurate results. Fig. 2 shows the system under study with a multi-MGs-based power distribution system having multiple distributed generators located inside the microgrids.

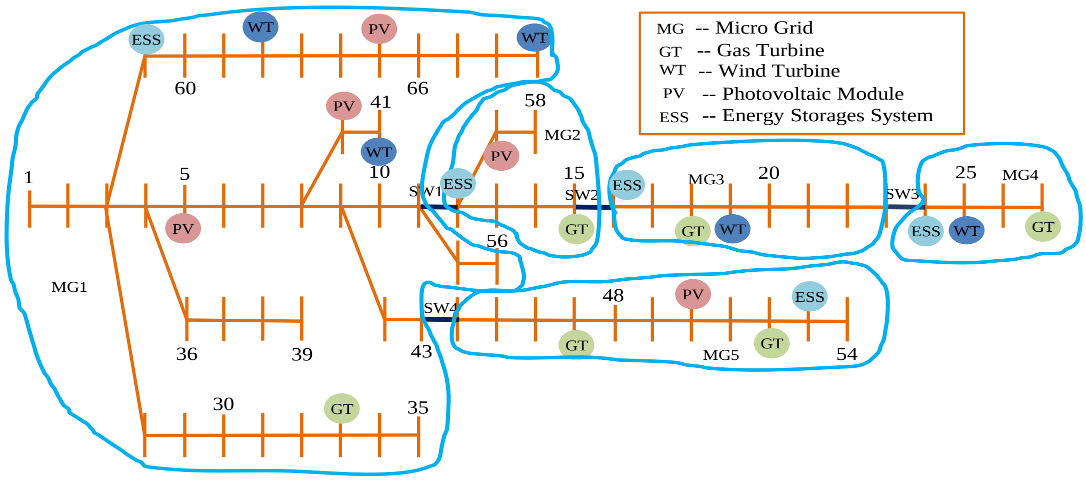


Figure 2: Multi microgrid power distribution system

VII. Results and Discussion

a) *Distributed Energy Resources Optimal Locations and Capacities inside Multi-MGs*

Two cases have been considered for finding optimal locations and capacities of distributed energy resources in this research.

Case I: 1125 kW of Distributed Energy Resources Operation: For the first cases, a total of 1125 kW of distributed energy resources integrates into multi-MGs where the contribution from the gas turbine is 500 kW, PV solar and wind turbine is 250 kW each, and energy storage is 125 kW. For the second case, a total of 2250 kW of distributed energy generators integrates into multi-MGs. In this case, there are 1000 kW of gas turbines, 500 kW of PVs and wind turbines, and 250 kW of energy storage present in the multi-MGs.

When a total of 1125 kW of distributed energy resources is included in multi-MGs, Table 1 shows corresponding capacities and locations. Before applying energy management in the operational setting, the planning stage is finding places and powers based on minimizing the multi-MG system losses and operating costs.

Table 1: Optimal locations and capacities of distributed energy resources

DG Name	Total Capcacity	Locations (Bus)	Capacities (kW)
Gas Turbine	500 kW	15, 33, 47, 52, 18	100, 100, 100, 120, 80
PV	250 kW	5, 57, 40, 30, 65	50, 50, 50, 70, 30
Wind Turbine	250 kW	41, 69, 19, 25, 63	50, 50, 50, 50, 50
Energy Storage System	125 kW	53, 59, 12, 24, 16	25, 25, 25, 40, 10

Table 1 shows the maximum capacity of gas turbines placed in bus number 52, where the lowest ability shows in bus number 18. A total of 500 kW gas turbines contributed to the system based on other distributed energy resources, capacities, and overall depend on system objectives. For PV solar, the maximum and minimum capacity is 70 kW and 30 kW, located in bus numbers 50 and 65, respectively. Noticeable that wind turbines are the same capacities in each location which is 50 kW. Interestingly, the lowest power ever shown for the energy storage system is 10 kW, which is on bus number 16.

Case II: 2250 kW of Distributed Energy Resources Optimal Operation: In this case, a total of 2250 kW of distributed energy resources integrates into multi-MGs, and Table 2 shows their corresponding locations and capacities. Gas turbines are a total of 1000 kW with five different areas.

Table 2: Optimal locations and capacities of distributed energy resources

DG Name	Total Capcacity	Locations (Bus)	Capacities (kW)
Gas Turbine	1000 kW	15, 33, 47, 52, 18	200, 200, 200, 240, 160
PV	500 kW	5, 57, 40, 30, 65	100, 100, 100, 140, 60
Wind Turbine	500 kW	41, 69, 19, 25, 63	100, 100, 100, 100, 100
Energy Storage System	250 kW	53, 59, 12, 24, 16	50, 50, 50, 80, 20

The highest power of the gas turbine is in bus number 52 with 240 kW, and the lowest capacity gas turbine is in bus number 18 with 160 kW. PV is in bus numbers 5, 57, 40, 50, and 65, where bus number 30 shows the highest capacity of 140 kW. Like the previous case, wind turbine capacities are the same in all five locations. Also, the maximum and minimum energy storage is in bus numbers 8 and 16 with 80 kW and 20 kW, respectively.

b) Multi-MGs Power Distribution System Operational Performance

When 1125 kW of distributed energy resources operate in multi-MGs, the corresponding multi-MGs operating performance indices are summarized in Table 3. The multi-MG operational commissions were calculated for two cases with and without considering flexible boundary condition. The reason for choosing the two mentioned cases was to see the contributions of flexible boundary condition in multi-MG controls and operations. Fig. 3 shows the multi-MG system with flexible boundary having multiple distributed generators located inside the microgrids.

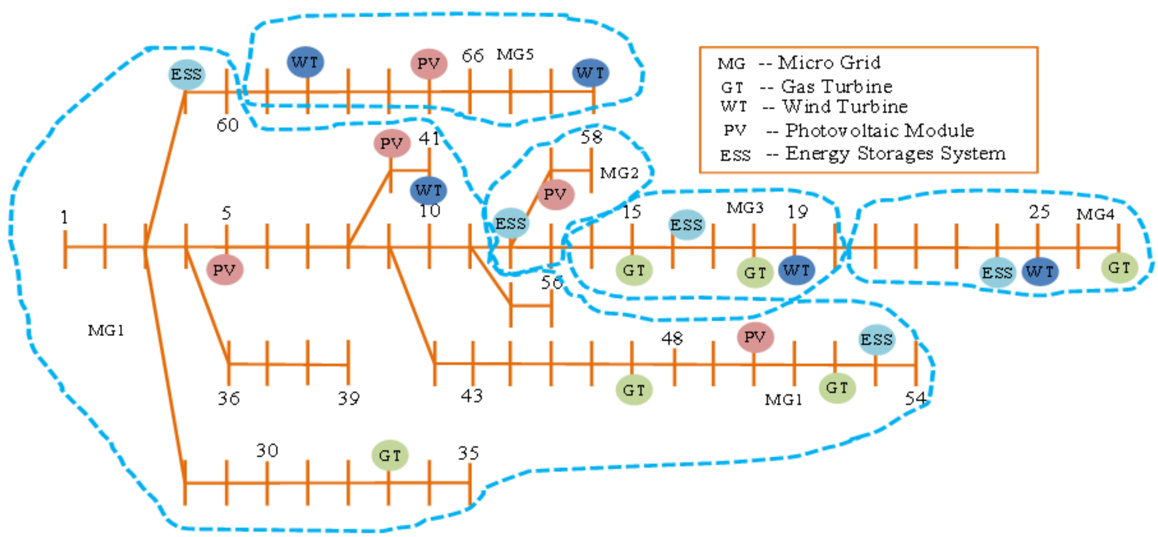


Figure 3: Multi microgrid power distribution system with flexible boundary condition

Table 3: Multi-MGs system operational performance indices for distributed energy resources optimal operations

Flexible Boundary	Emission	System Loss	Total cost
No	$ 211.5	$ 325.7	$ 7635
Yes	$ 205.6	$ 98.7	$ 7175

It is seen from Table 3 that the total operating costs for multi-MGs reduced to $ 7175 from $ 7635 due to the advantages of flexible boundary conditions inside multi-MGs. The significant changes happen for the multi-MG operating loss reduction where it reduces from $ 325.7 to $ 98.7 for optimal operation of existing distributed resources considering flexible boundaries. A similar deduction is observed for system emissions.

Moreover, when 2250 kW of distributed energy resources operate in multi-MGs, the corresponding multi-MGs operational performance indices are summarized in Table 4. Like as 1125 kW of distributed energy resources operations, for the case of 2250 kW, this research also considers the same two cases with and without considering flexible boundary conditions for finding multi-MGs operating performance indices.

Table 4: Multi-MGs system operational performance indices for distributed energy resources optimal operations

Flexible Boundary	Emission	System Loss	Total cost
No	$ 193.8	$ 267.6	$ 6201.2
Yes	$ 189	$ 81.6	$ 5824.2

For the operation of 2250 kW of distributed energy resources in multi-MGs, the system gets more benefit in terms of operational performance. For instance, the results presented in Table 4 show that the total operating costs reduced to $ 5824.2 from $ 6201.2 due to the advantages of flexible boundary conditions inside multi-MGs. Like the previous case of 1125 kW, significant changes happen for the loss reduction where the loss reduces from $ 267.6 to $ 81.6 for optimal operation of existing distributed resources considering flexible boundaries, which is also less than the previous case of 1125 kW. A similar deduction is observed for system emissions as well.

VIII. Impact of IOT in Multi-mgs Operations

In this research, IoT plays a crucial role in the real-time operation and is controlled for multi-MGs. If IoT is not implemented for microgrid operation, there will be a delay in communication, causing delays in detection of load and generation changes. This would affect the overall system performance and lower its efficiency. In previous sections, IoT is considered to ensure that there will not be any delays between generations and loads while performing simulations. This section is specifically showing and comparing the impacts of having or not having IoT for operation of multi-MGs, with and without flexible boundaries. For case 1, 1125 kW of distributed energy resources operation in multi-MGs, the results would be worse than expected, if IoT is not considered.

Table 5: IoT impacts for 1125 kW of distributed energy generations in multi-MG

Flexible Boundary	Emission	System Loss	Total cost
No	$ 218.2	$ 347.1	$ 7887.5
Yes	$ 211.8	$ 104.6	$ 7396.8

Table 5 shows that the total operating costs go higher to $ 7887.5 from the typical operating expenses of $ 7635 with the same distributed energy generation operation capacities in multi-MGs without considering flexible bounder conditions. Even for the relaxed boundary condition, operating costs increase to $ 7396.8 from $ 7175 due to not considering IoT for multi-MG operations. Similar increment patterns are showing for the system loss and emissions as well.

Table 6: IoT impacts for 2250 kW of distributed energy generations in multi-MG

Flexible Boundary	Emission	System Loss	Total cost
No	$ 199.94	$ 284.98	$ 6406.1
Yes	$ 194.75	$ 86.67	$ 6004.3

For the operation of 2250 kW of distributed energy resources in multi-MGs, operational costs, losses, and emissions are worse than before. In this case, Table 6 shows that the total operating expenses go higher to $ 6406.1 from the typical operational costs of $ 6201 shown in Table 4 with the same distributed energy generation operation capacities in multi-MGs without considering flexible boundary conditions. Similarly, even for the relaxed boundary condition, operating costs go high to $ 6004.3 from $ 5824.2 shown in Table 4 due to not considering IoT for multi-MG operations. Similar increment patterns are offered for the system loss and emissions as well.

IX. Conclusions

This research develops a model for optimal operation of various distributed energy resources in a multi-MG power distribution network which helps for increasing multi-MG system efficiency. The model explores energy management, IoT, and flexible

Global Journal of Researches in Engineering (F) Volume XXII Issue II Version I Year 2022

boundary conditions during distributed energy resources operation. It is seen that more benefits are achievable during energy sharing between microgrids operating as multi-MGs. A comparatively new hybrid PSO-TS algorithm is used for optimizations in the PG&E 69-bus multi-MG distribution system. Case studies show that optimal operating strategies between various energy resources in a multi-MG reduce the total operating costs to $ 7396.8 from $ 7635 due to flexible multi-MGs boundary conditions for 1500 kW energy resources. More benefits can be obtained from the application of IoT with flexible boundary MGs, where the total operating costs further reduces to $ 7175 from $ 7396.8. Since there are uncertainties related to renewable-based energy re-sources, corresponding uncertainty paraments are included during system modeling to ensure accurate results. Future work may consist of multi-MG system resiliency and reliability as an objective function while considering IoT and flexible boundary within multi-MG.

References Références Referencias

1. A. Hussain, V. Bui and H. Kim, "An Effort-Based Reward Approach for Allocating Load Shedding Amount in Networked Microgrids Using Multiagent System," in IEEE Transactions on Industrial Informatics, vol. 16, no. 4, pp. 2268-2279, April 2020.
2. M. Dabbaghjamanesh, A. Kavousi-Fard and S. Mehraeen, "Effective Scheduling of Reconfigurable Microgrids With Dynamic Thermal Line Rating," in IEEE Transactions on Industrial Electronics, vol. 66, no. 2, pp. 1552-1564, Feb. 2019.
3. A. L. Dimeas and N. D. Hatziargyriou, "Operation of a multiagent system for microgrid control," in IEEE Transactions on Power Systems, vol. 20, no. 3, pp. 1447-1455, Aug. 2005.
4. H. S. V. S. Kumar Nunna and S. Doolla, "Multiagent-Based Distributed-Energy-Resource Management for Intelligent Microgrids," in IEEE Transactions on Industrial Electronics, vol. 60, no. 4, pp. 1678-1687, April 2013.
5. K. Moslehi and A. B. R. Kumar, "Autonomous Resilient Grids in an IoT Landscape Vision for a Nested Transactive Grid," in IEEE Transactions on Power Systems, vol. 34, no. 5, pp. 4089-4096, Sept. 2019.
6. A. J. Ortiz-Larquin, J. Diaz-Carmona, E. Rodríguez-Segura, A. Espinosa-Calderon, J. Prado-Olivarez and A. Padilla-Medina, "IoT-CAN based system for remote monitoring and control of DC microgrids," 2021 44th International Conference on Telecommunications and Signal Processing (TSP), Brno, Czech Republic, 2021, pp. 305-308.
7. Arbab-Zavar, Babak, Emilio J. Palacios-Garcia, Juan C. Vasquez, and Josep M. Guerrero. 2021. "Message Queuing Telemetry Transport Communication Infrastructure for Grid-Connected AC Microgrids Management" Energies 14, no. 18: 5610. https://doi.org/10.3390/en14185610.
8. S. Ahn, S. Nam, J. Choi and S. Moon, "Power Scheduling of Distributed Generators for Economic and Stable Operation of a Microgrid," in IEEE Transactions on Smart Grid, vol. 4, no. 1, pp. 398-405, March 2013.
9. Y. Jia, X. Lyu, P. Xie, Z. Xu and M. Chen, "A Novel Retrospect-Inspired Regime for Microgrid Real-Time Energy Scheduling With Heterogeneous Sources," in IEEE Transactions on Smart Grid, vol. 11, no. 6, pp. 4614-4625, Nov. 2020.
10. Di Wu, Xu Ma, Sen Huang, Tao Fu, and Patrick Balducci" Stochastic optimal sizing of distributed energy resources for a cost-effective and resilient Microgrid," in Energy, Volume 198, 1 May 2020, 117284, Elsevier Ltd.
11. Ghanbari, Niloofar, Hossein Mokhtari, and Subhashish Bhattacharya. 2018. "Optimizing Operation Indices Considering Different Types of Distributed Generation in Microgrid Applications" Energies 11, no. 4: 894. https://doi.org/10.3390/en11040894.
12. H. A. U. Muqeet and A. Ahmad, "Optimal Scheduling for Campus Prosumer Microgrid Considering Price Based Demand Response," in IEEE Access, vol. 8, pp. 71378-71394, 2020.
13. T. Zhao, Z. Li and Z. Ding, "Consensus-Based Distributed Optimal Energy Management With Less Communication in a Microgrid," in IEEE Transactions on Industrial Informatics, vol. 15, no. 6, pp. 3356-3367, June 2019.
14. W. Liu, W. Gu, J. Wang, W. Yu and X. Xi, "Game Theoretic Non-Cooperative Distributed Coordination Control for Multi-Microgrids," in IEEE Transactions on Smart Grid, vol. 9, no. 6, pp. 6986-6997, Nov. 2018.
15. J. Li, M. E. Khodayar, J. Wang and B. Zhou, "Data-Driven Distributionally Robust Co-Optimization of P2P Energy Trading and Network Operation for Interconnected Microgrids," in IEEE Transactions on Smart Grid, vol. 12, no. 6, pp. 5172-5184, Nov. 2021.
16. P. Sheikhahmadi, S. Bahramara, S. Shahrokhi, G. Chicco, A. Mazza and J. P. S. Catalão, "Modeling Local Energy Market for Energy Management of Multi-Microgrids," *2020 55th International Universities Power Engineering Conference (UPEC)*, Turin, Italy, 2020, pp. 1-6.
17. Y. Jia, P. Wen, Y. Yan and L. Huo, "Joint Operation and Transaction Mode of Rural Multi Microgrid and Distribution Network," in IEEE Access, vol. 9, pp. 14409-14421, 2021.
18. Z. Liu, L. Wang and L. Ma, "A Transactive Energy Framework for Coordinated Energy Management of

Networked Microgrids With Distributionally Robust Optimization," in IEEE Transactions on Power Systems, vol. 35, no. 1, pp. 395-404, Jan. 2020.

19. Hasanvand, S., Nayeripour, M., Arefifar, S. A., & Fallahzadeh-Abarghouei, H. (2018). Spectral clustering for designing robust and reliable multi-MG smart distribution systems. *IET Generation, Transmission & Distribution*, *12*(6), 1359-1365. M. E. Nassar and M. M. A. Salama, "Adaptive Self-Adequate Microgrids Using Dynamic Boundaries," in *IEEE Transactions on Smart Grid*, vol. 7, no. 1, pp. 105-113, Jan. 2016.
20. T. Zhao, J. Wang and X. Lu, "An MPC-Aided Resilient Operation of Multi-Microgrids With Dynamic Boundaries," in *IEEE Transactions on Smart Grid*, vol. 12, no. 3, pp. 2125-2135, May 2021.
21. A. Mohsenzadeh, C. Pang and M. Haghifam, "Determining Optimal Forming of Flexible Microgrids in the Presence of Demand Response in Smart Distribution Systems," in *IEEE Systems Journal*, vol. 12, no. 4, pp. 3315-3323, Dec. 2018.
22. G. Bedi, G. K. Venayagamoorthy, and R. Singh, "Navigating the challenges of Internet of Things (IoT) for power and energy systems," in Proc. Clemson Univ. Power Syst. Conf. (PSC), Clemson, SC, USA, 2016, pp. 1–5.
23. M. S. Alam and S. A. Arefifar, "Hybrid PSO-TS Based Distribution System Expansion Planning for System Performance Improvement Considering Energy Management," in IEEE Access, vol. 8, pp. 221599-221611, 2020.
24. M. S. Alam and S. A. Arefifar, "Cost & Emission Analysis of Different DGs for Performing Energy Management in Smart Grids," 2018 IEEE International Conference on Electro/Information Technology (EIT), Rochester, MI, USA, 2018, pp. 0667-0672.
25. S. Pinheiro, C. R. R. Dornellas, and A. C. G. Melo, "Probing the new IEEE reliability test system (RTS-96): HL-II assessment," IEEE Trans. Power Syst., vol. 13, no. 1, pp. 171–176, Feb. 1998.
26. B. Yuan, A. Chen, C. Du and C. Zhang, "Hybrid AC/DC microgrid energy management based on renewable energy sources forecasting," 2017 36th Chinese Control Conference (CCC), Dalian, China, 2017, pp. 2870-2875.

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 22 Issue 2 Version 1.0 Year 2022
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Automatic Generation Control and Automatic Voltage Regulator Design for Load Frequency Control of Interconnected Thermal Power System

By Omer Elmukhtar & Jianhua Zhang
North China Electric Power University

Abstract- This paper presents a new model for each component of Automatic generation control (AGC) and automatic voltage regulator (AVR) loops considering generator rate constraints (GRC) of one and two areas interconnected thermal power system. Any mismatch between system generation and demand results in a change in system frequency that is highly undesired. Excitation of the generator must be regulated in order to match the power demand, otherwise, the bus voltage may fall beyond the permitted limit. In this paper, a simulation model is developed for each component of AGC and AVR loops considering generator rate constraints.

Keywords: automatic generation control (AGC); automatic voltage regulator (AVR); automatic load frequency control (ALFC); generation rate constraint (GRC).

GJRE-F Classification: *DDC Code: 621.31 LCC Code: TK153*

Automatic Generation Control and Automatic Voltage Regulator Design for Load Frequency Control of Interconnected Thermal Power System

Omer Elmukhtar [α] & Jianhua Zhang [σ]

Abstract- This paper presents a new model for each component of Automatic generation control (AGC) and automatic voltage regulator (AVR) loops considering generator rate constraints (GRC) of one and two areas interconnected thermal power system. Any mismatch between system generation and demand results in a change in system frequency that is highly undesired. Excitation of the generator must be regulated in order to match the power demand, otherwise, the bus voltage may fall beyond the permitted limit. In this paper, a simulation model is developed for each component of AGC and AVR loops considering generator rate constraints. Although the frequency variation was found to be less with suitable controllers when the GRC is not considered, it is not the frequency variation. The frequency variation can be found when GRC is considered and then accordingly the controller is tuned. So that the required frequency and power interchange with adjacent structures are maintained in order to minimize the transient deviations and to provide zero steady-state error in a proper short time, the response without GRC is compared with the analysis done with the GRC, the behaviour of the planned is checked by MATLAB SIMULINK software.

Keywords: automatic generation control (AGC); automatic voltage regulator (AVR); automatic load frequency control (ALFC); generation rate constraint (GRC).

I. Introduction

The load frequency control problem discussed so far does not consider the effect of the restrictions on the rate of change of power generation. In power systems having steam plants, power generation can change only at a specified maximum rate. The generation rate for reheat units is quite low. Several methods have been proposed to consider the effect of GRC. The system dynamic model becomes non-linear and linear control techniques cannot be applied for the optimization of the controller setting.

Load frequency control (LFC) performs a very important role in power stability between load and generation sides. In the latest years, many robust design strategies have been delivered for LFC[1-3] the dynamic behaviour of the many industrial plants are heavily influenced by means of disturbances and, in particular, by adjustments in the operating point. This is often sometimes typically the case for power systems [4]. Automatic Generation Control (AGC) is the most necessary problems in electric strength machine sketch and operation. The goal of the AGC in an interconnected strength machine is to hold tie-line electricity strength and to keep the frequency of every area shut to the scheduled values through adjusting the MW outputs of the AGC generators which will accommodate fluctuating load demands [5]. The generator excitation device keeps the generator voltage and controls the reactive electricity flow. A generator excitation of the older system may additionally be furnished via slip rings and brushes via implying of DC generator hooked up on the equal shaft as the rotor of the synchronous motor [6].

Obviously, trade in the real electricity demand impacts if truth be told the frequency, whereas a change in the actual strength influences by the voltage magnitude. The communication between frequency control and voltage is typically weak enough to justify their analysis separately. The sources of reactive strength are generators, capacitors, and reactors [7].

Generators with identical response characteristics for load variations assembled together to meet a particular load demand is referred to as the area. These areas are interconnected with tie lines these tie lines are used to alternate energy between areas, which will increase fault level and inter-area support just in case of abnormal situations [8-10]. The area may also have mixed of various sources combination of different sources in this paper every area consists of thermal with reheat type turbine system, fuel electricity technology hydro, gas power generation [11]. The conventional control approach for the frequency regulation problem is based totally on applying corrective signal governor summing point using PI, PID controllers. These controllers achieve zero steady-state error however dynamic performance exhibited by these controllers may be very poor. Greater over PI, PID controllers fail to

Author α: Department of Computer Science and Control Engineering North China Electric Power University, Beijing, China.
e-mail: omer90mizo@ncepu.edu.cn
Author σ: State Key Laboratory of Alternate Electrical Power System with Renewable Energy Sources, North China Electric Power University, Beijing, China.

Global Journal of Researches in Engineering (F) Volume XXII Issue II Version I Year 2022

provide satisfactory performance over a variety of operating conditions.

A literature review on LFC shows varied control strategies have been utilized for the load frequency control problem. Optimal state feedback control approaches, sub-optimal state feedback controllers are projected in [12-13] Adaptive and self-tuning methods are proposed in [14-15] Evolutionary algorithms like GA, PSO, optimization, bacterial foraging, etc. applied by several authors [16-19]. In an extensive literature survey, LFC shows that LFC with ANN & Fuzzy logic control application providing better performance for load frequency control problems [19-22].

II. Automatic Generation Control

The first procedure in the analysis and design of a control system is the construction of mathematical modelling of the system. The two most common methods are the transfer function method and the state variable approach. The state variable methodology can be applied to model linear as well as nonlinear systems. So as to use the transfer function and linear state equations, the system initially is linearized appropriate assumptions and approximations are made to linearize the mathematical equations describing the system. A transfer function model is obtained for the following components.

a) Generator Load Model

Gives the relation between the changes in frequency (Δf) as a change by a small amount (ΔPD). Neglecting the change in generation losses,

$$\Delta F(s) = \Delta P_G(s) - \Delta P_D(s)\frac{KP_S}{1+sTP_S} \quad (1)$$

TPS is a power system time constant

KPS is a power system gain

b) Prime Mover Model

he model for the turbine relates modifications in mechanical power output ΔPt(s) to modifications in steam valve position, the simplest prime mover model for the non-reheat steam turbine can be approximated with a single time constant (Tt), resulting in the following transfer function:

$$\frac{\Delta P_t(s)}{\Delta y_E(s)} = \frac{K_t}{1+ST_t} \quad (2)$$

c) Speed Governor Model

Most modem governors use electronic means to sense speed changes.

$$\Delta Y_E(s) = \Delta P_c(s) - \frac{1}{R}\Delta f(s) \times \frac{K_{sg}}{1+T_{sg}(s)} \quad (3)$$

R = Speed regulation of the governor

KSg = Gain of speed governor

Tg (s) = Time constant of speed governor

III. Area Control Error of Two Areas

The normal switch characteristic of the mannequin is Let us now flip our attention to ACE (area control error) in the presence of a tie line. In the case of an isolated manage area, ACE is the exchange in place frequency which when used in crucial manage loop forces the steady country frequency error to zero. In order that the regular country tie line strength error in a two-area manipulate be made zero every other control loop (one for every area) has to be brought to combine the incremental tie line strength signal and feed it lower back to velocity changer. This is performed by using a single line-integrating block through redefining ACE as a linear combination of incremental frequency and tie-line power.

IV. Automatic Voltage Regulator

AVR is an important part of a synchronous generator. The AVR is used for regulating the terminal voltage of the synchronous generator. Whenever, there is an unexpected drop in voltage due to accidents, faults or common changes in loading. The AVR improves the transient stability of a system.

a) Amplifier Model

The comparator continuously compares the reference voltage Vref and actual output voltage Vt and generates voltage error signal, which is fed to the amplifier. The amplifier can be magnetic, rotational or electronic type. Due to the delay in the response of the amplifier, its transfer function (T. FA) is given by:

$$T.F_A = \frac{K_A}{1+ST_A} = \frac{\Delta V_R(S)}{\Delta V_T(S)} \quad (4)$$

Where ΔVR (S) is the amplifier output and ΔVT (S) is the error voltage and is given by:

$$\Delta V_T(S) = V_{ref} - V_T \quad (5)$$

b) Exciter

In the simplest form, the transfer function of the modern exciter may be represented by the single time constant TE and gain KE,

$$T.F_A = \frac{K_E}{1+ST_E} = \frac{\Delta V_F(S)}{\Delta V_R(S)} \quad (6)$$

Where ΔVF (S) is the field voltage of the synchronous generator, the time constant of the modern exciter is very small.

Global Journal of Researches in Engineering (F) Volume XXII Issue II Version I Year 2022

c) Generator Field Model

The synchronous machine generated EMF is a function of the magnetization curve, and it's terminal voltage is dependent on the generator load.

$$T.F_G = \frac{K_R}{1+ST_R} = \frac{\Delta V_T(S)}{\Delta V_F(S)} \qquad (7)$$

d) Sensor Model

The sensor sensed voltage through a potential transformer.

$$T.F_S = \frac{K_R}{1+ST_R} = \frac{\Delta V_S(S)}{\Delta V_T(S)} \qquad (8)$$

a) Two Areas Load Frequency Control

Figure 1 represented the simulation of the block diagram of two areas.

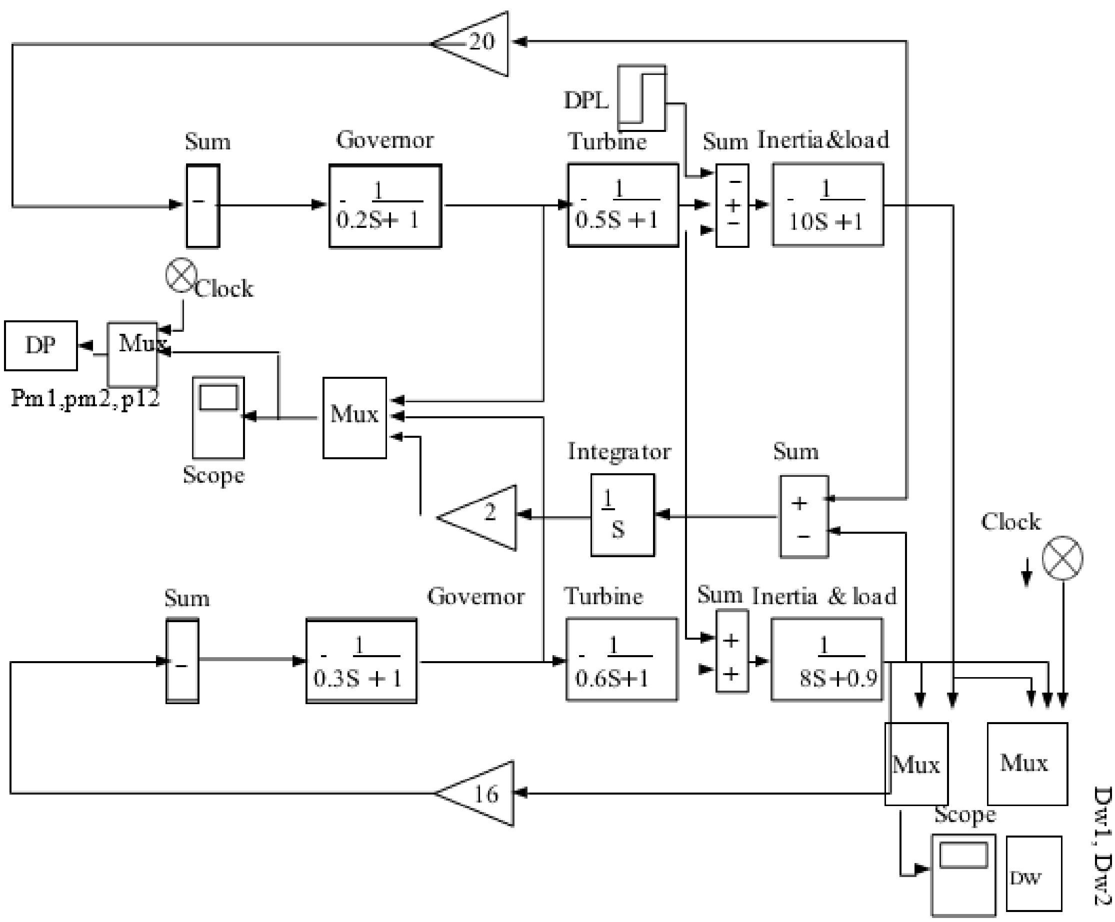


Figure 1: Model of two areas load frequency control

V. Simulation and Results

The design and simulation of the system are analysing using MATLAB SIMULINK environment. And it's using it to testing the individual blocks of automatic voltage control and automatic voltage regulator system of single and two areas with generation rate constraint and used area control error to improve the dynamic response and to reduce the steady-state error to zero.

In this study there are many assumptions, the model of thermal generation plant, also the system with two control areas that had one tie line between them and the basic block diagram for a single and two areas AGC, the system is in a normal operating mode and the loss of a generating unit will not be considered.

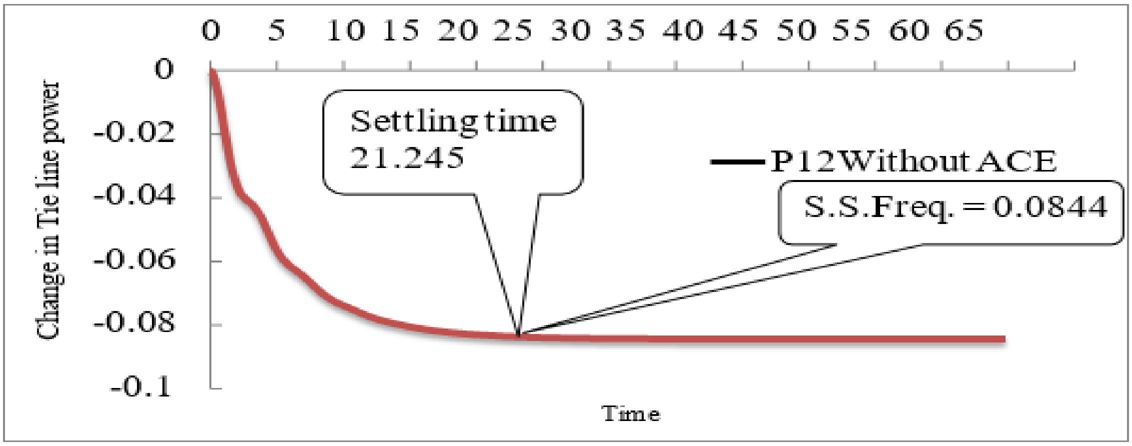


Figure 2: Change in tie-line power

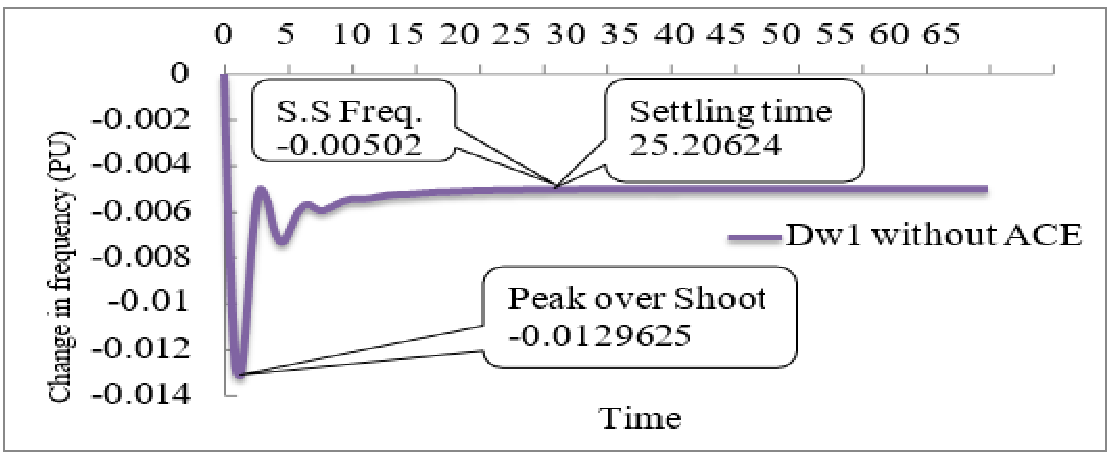


Figure 3: Change in frequency of area one without ACE

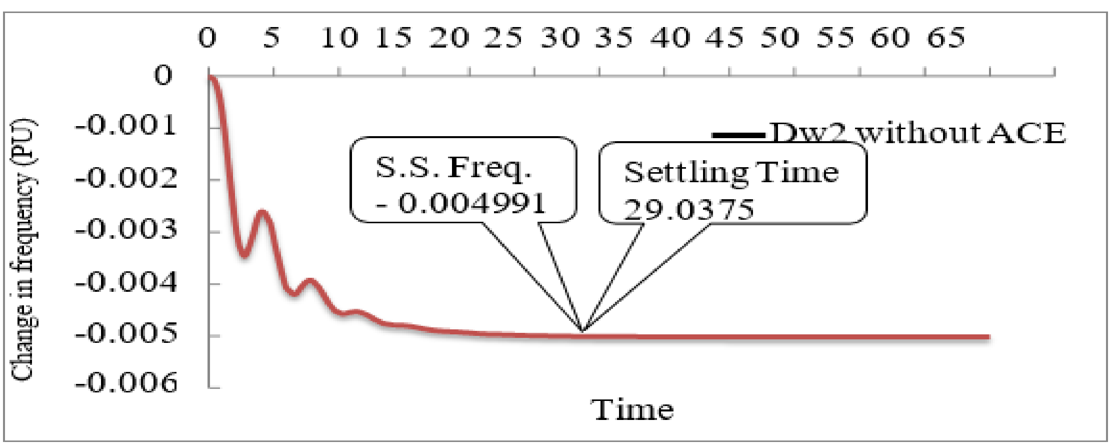


Figure 4: Change in frequency of area two without ACE

Figure 4 shows the schematic of the LFC of the 2-area system without the secondary loop while figures 2, 3, 4 shows the simulation results. As the two systems are interconnected, the frequency drifts of the two will settle down to equal value after some oscillations. The mechanical inputs of the two vary to reduce the mismatched power between the electrical load in area 1 and the mechanical inputs. It can also be observed that area 2 will generate excess power to share the load change in area1. It can observe the tie-line power flow following a load disturbance in area 1. Compared to the same result with the system, I appreciated the stability improvement with interconnection.

b) Two Areas Load Frequency Control with Area Control Error

The tie line deviation reflects the contribution of the regulation characteristic of one area to another. The basic objective of supplementary control is to restore the balance between each area load generation. This objective is met when the control action maintains frequency at the scheduled value. The supplementary control should ideally correct only for changes in that area. In other words, if there is a load change in Area1, there should be supplementary control only in Area1 and not in Area2. For this purpose, the area control error (ACE) is used.

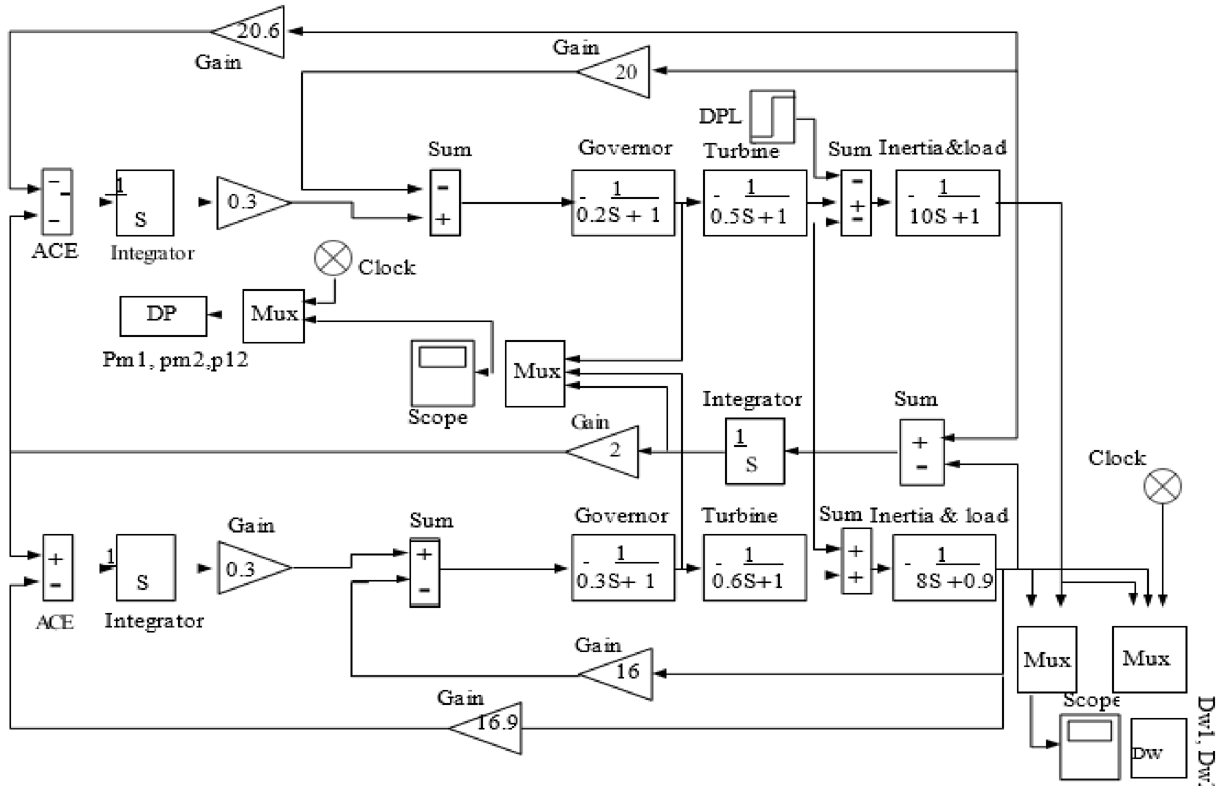


Figure 5: Model of two areas loads frequency control with area control error

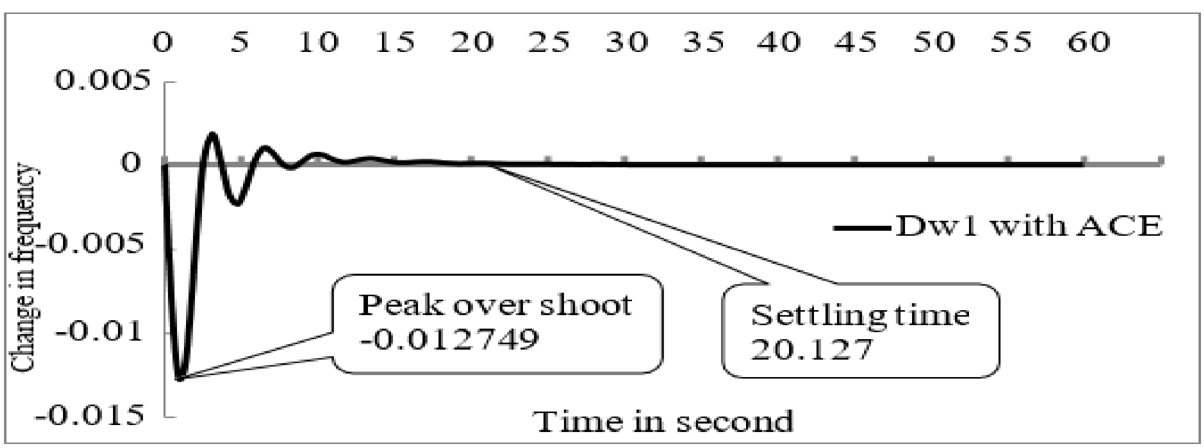


Figure 6: Change in frequency of area one with ACE

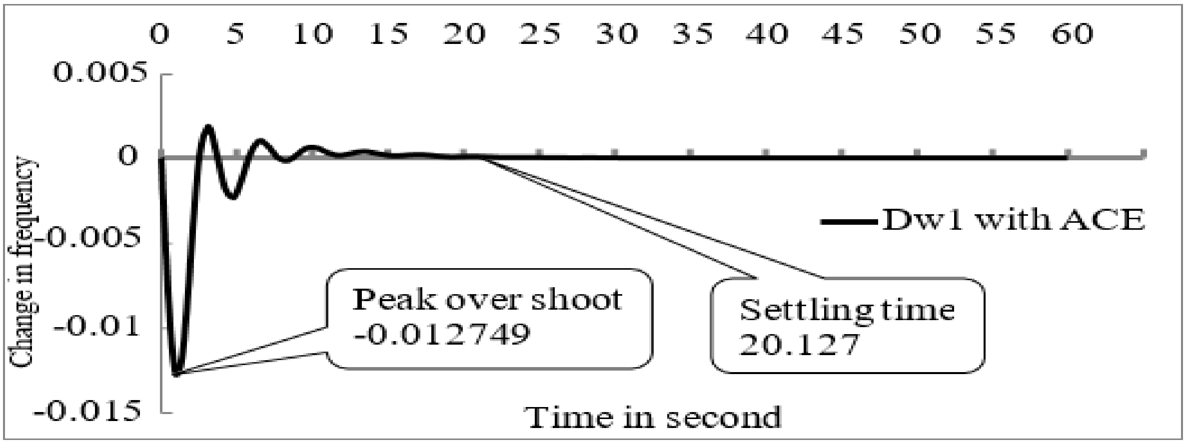


Figure 7: Change in frequency of area one with ACE

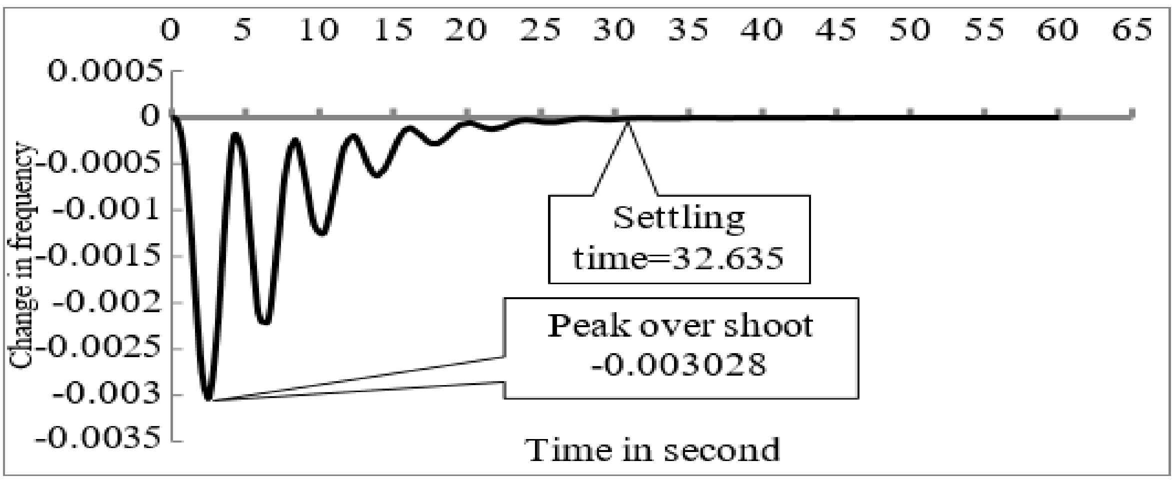


Figure 8: Change in frequency of area two with ACE

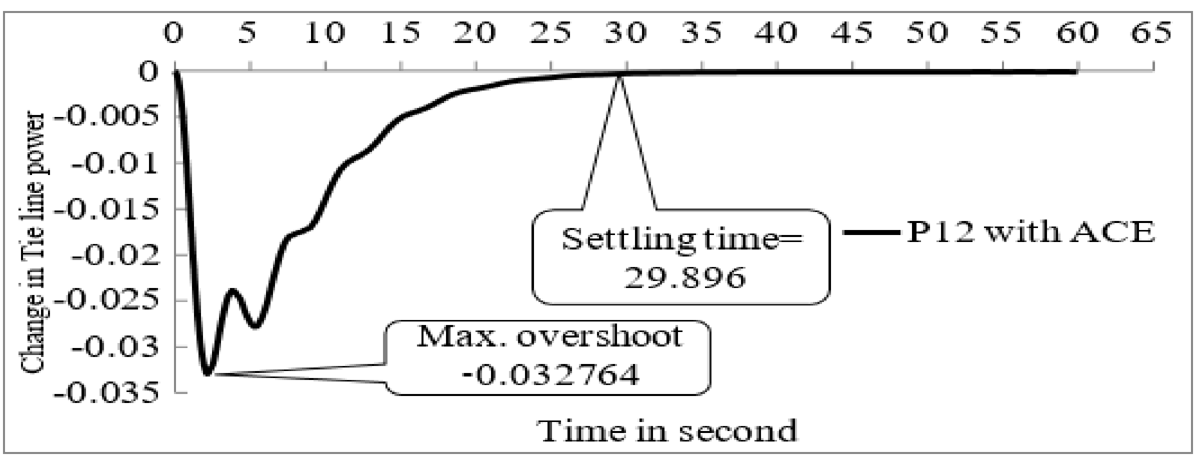


Figure 9: Tie line of two areas with ACE

As seen from the figures the secondary loop causes the return of frequency drifts to zero.

From the above simulation plots, it can be observed that the system experiences frequency drift following a load disturbance and it is mainly due to the mismatch between the electrical load and the mechanical input to the turbine. The system oscillation is serious in single area system compared to two area system because all the load change in load is to be met by only one area. Also, using the second loop in both the single area as well as the two area system the change in frequency is brought to zero.

c) Two Areas Load Frequency Control with Generation Rate Constraint

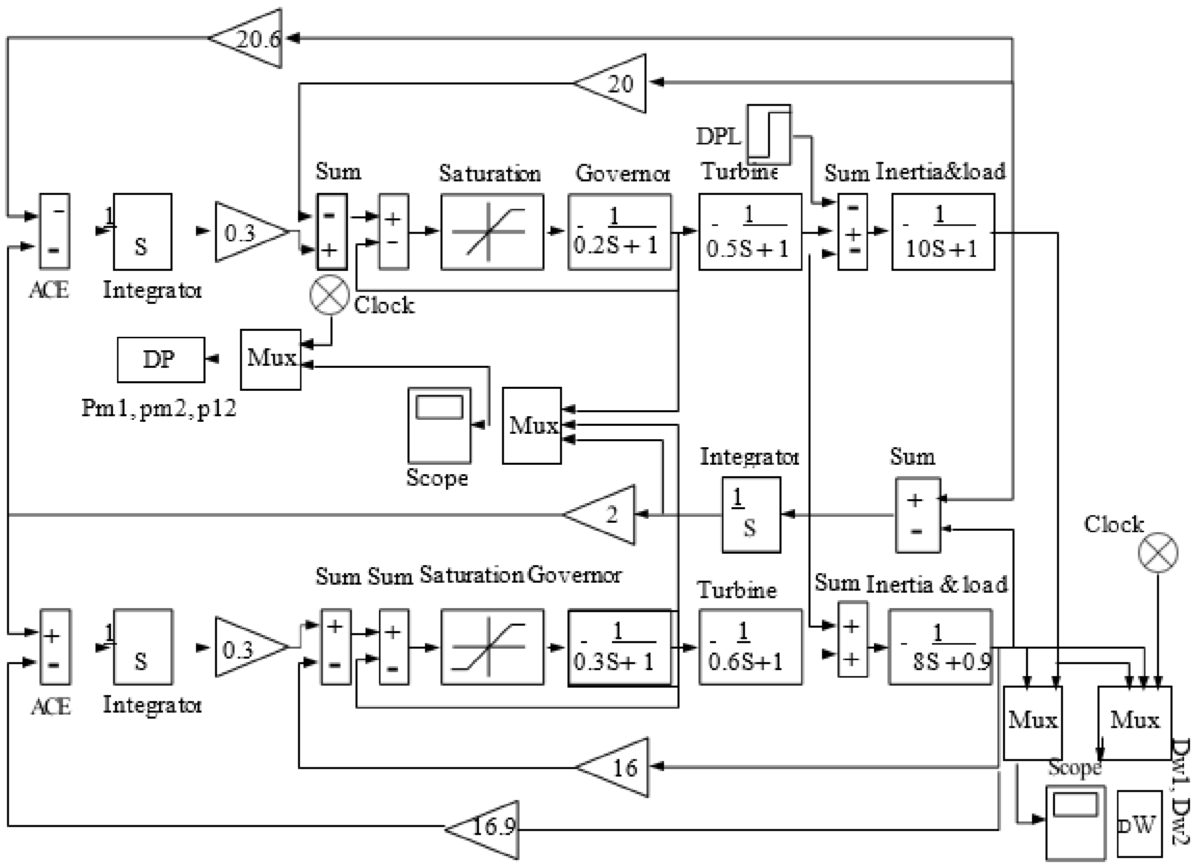


Figure 10: Models of two areas with generation rate constraint

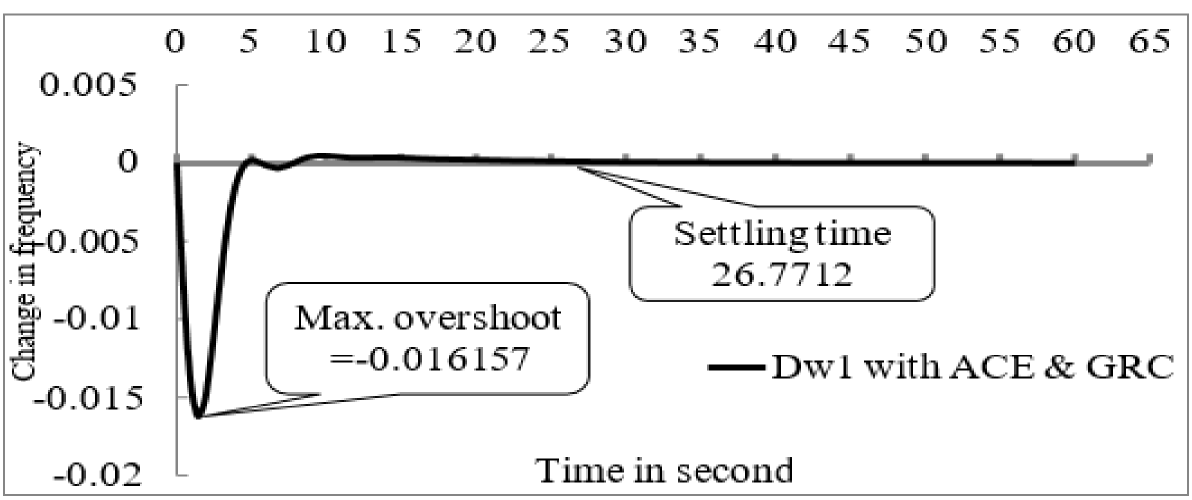


Figure 11: Change in frequency of area one with ACE and GRC

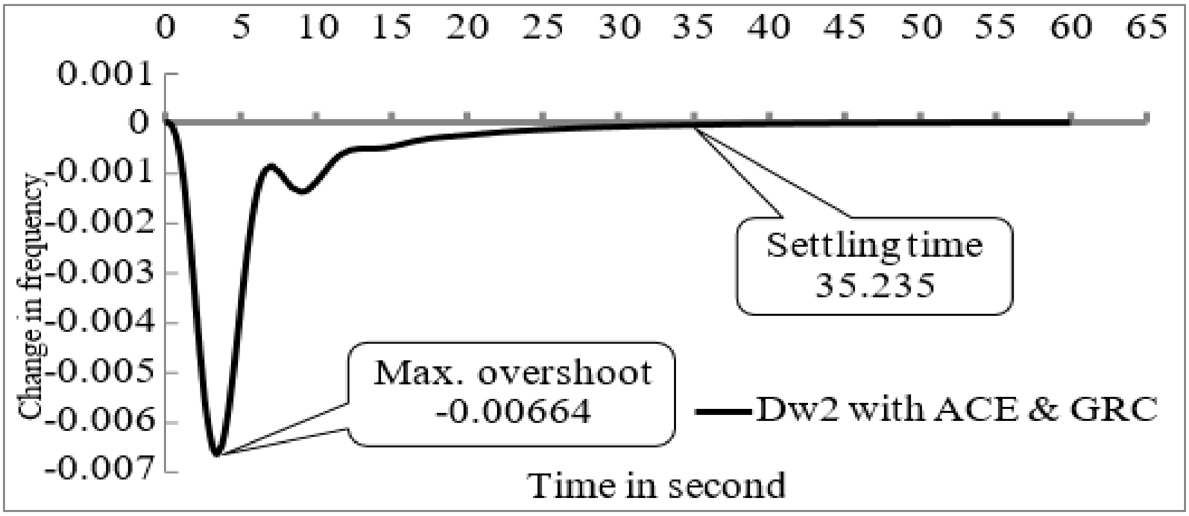


Figure 12: Change in frequency of two areas with ACE and GRC

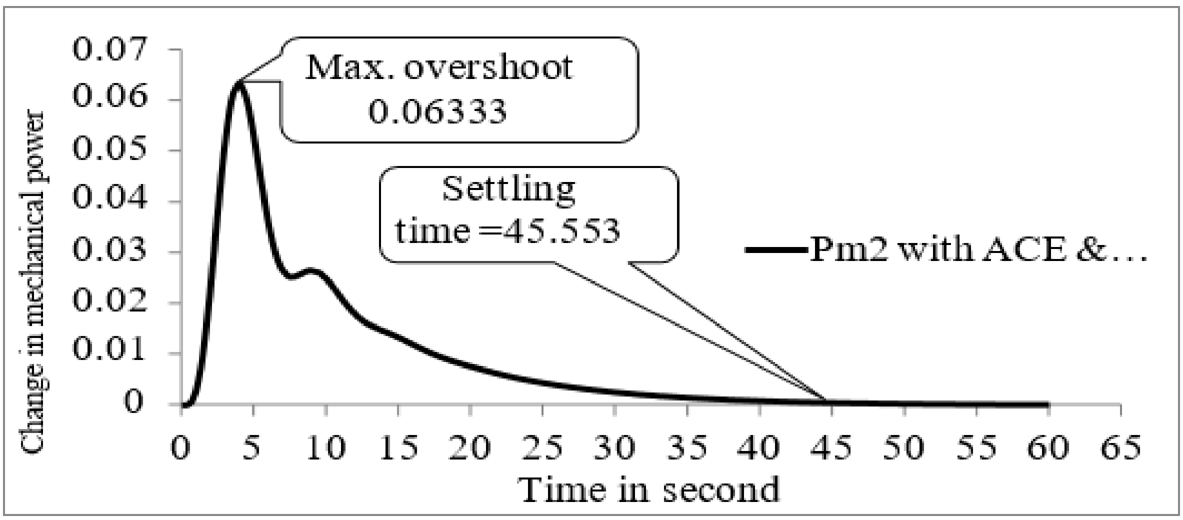


Figure 13: Change in mechanical power of area two with ACE and GRC

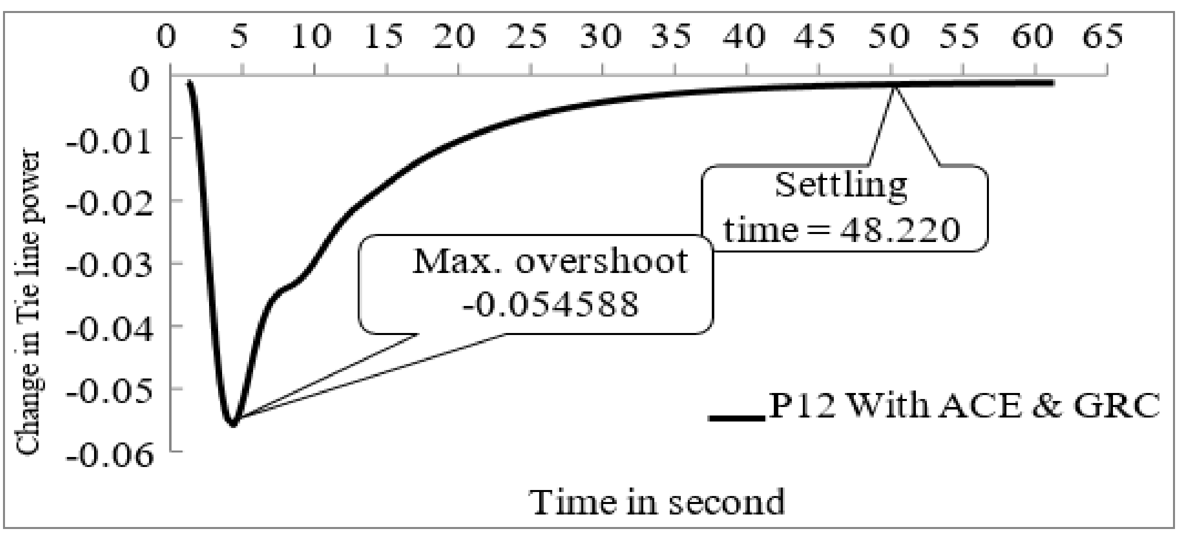


Figure 14: Change in tie-line power of two areas with ACE and GRC

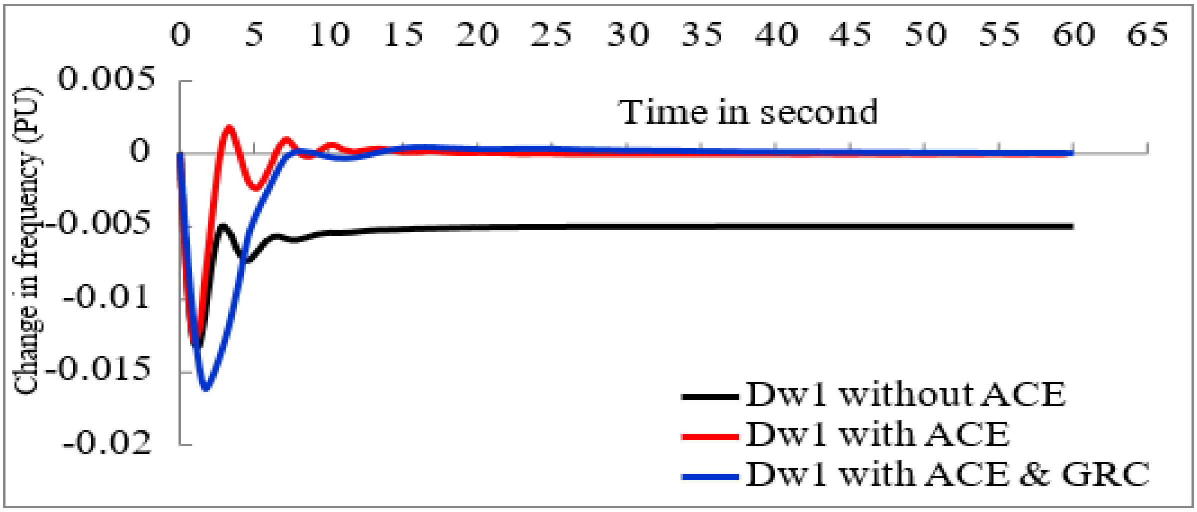


Figure 15: Comparisons between Dw1 with and without ACE & GRC

Table 1: Represent summary of figure 15

	Peak over shoot	S.S.Freq.	Settling time
First order	-0.01296	-0.00502	25.20624
Without ACE	-0.012749	0.0	20.1273
With ACE	-0.016157	0.0	26.7712

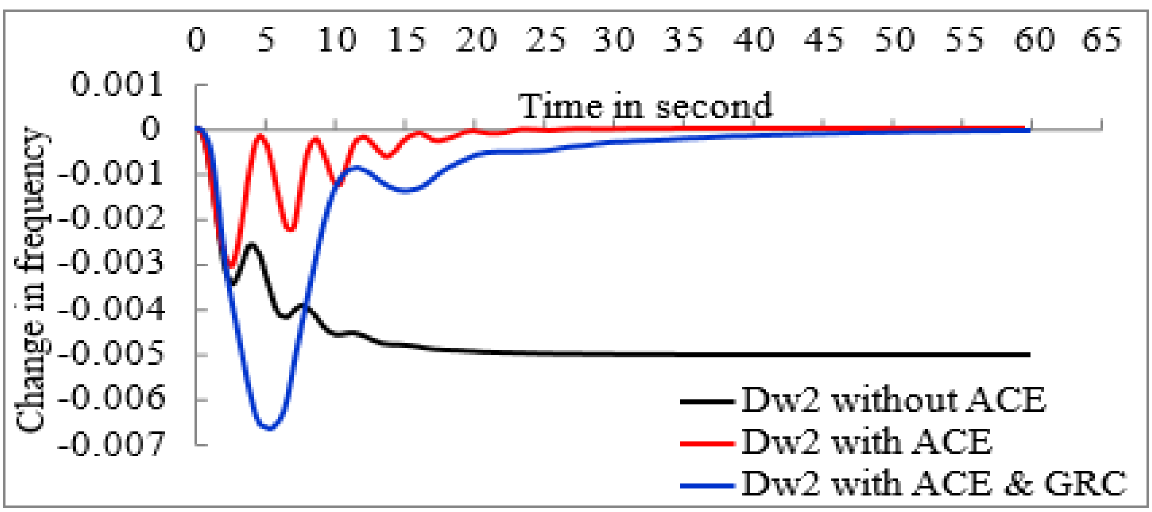


Figure 16: Comparisons between Dw2 with and without ACE & GRC

Table 2: Represent summary of figure 16

	Peak over shoot	S.S.Freq.	Settling time
Without ACE	-0.004991	-0.004991	29.037
With ACE	-0.003028	0.0	32.635
With GRC	-0.00664	0.0	35.235

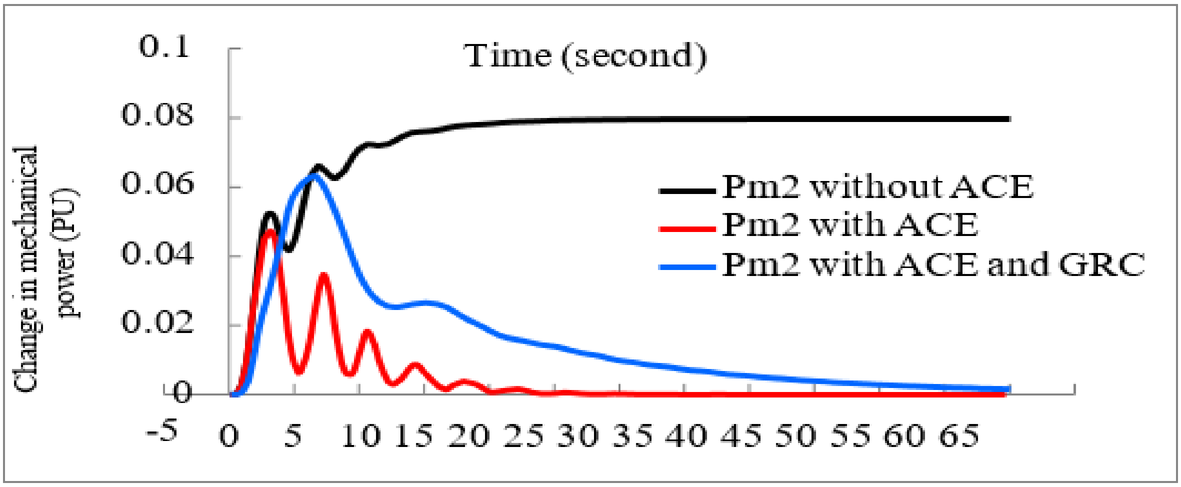


Figure 17: Comparisons between Pm2 with and without ACE & GRC

Table 3: Represent summary of figure 17

	Peak over shoot	S.S.Freq.	Settling time
Without ACE	0.07996	0.07996	25.206
With ACE	0.04721	0.0	32.452
With GRC	0.06333	0.0	45.553

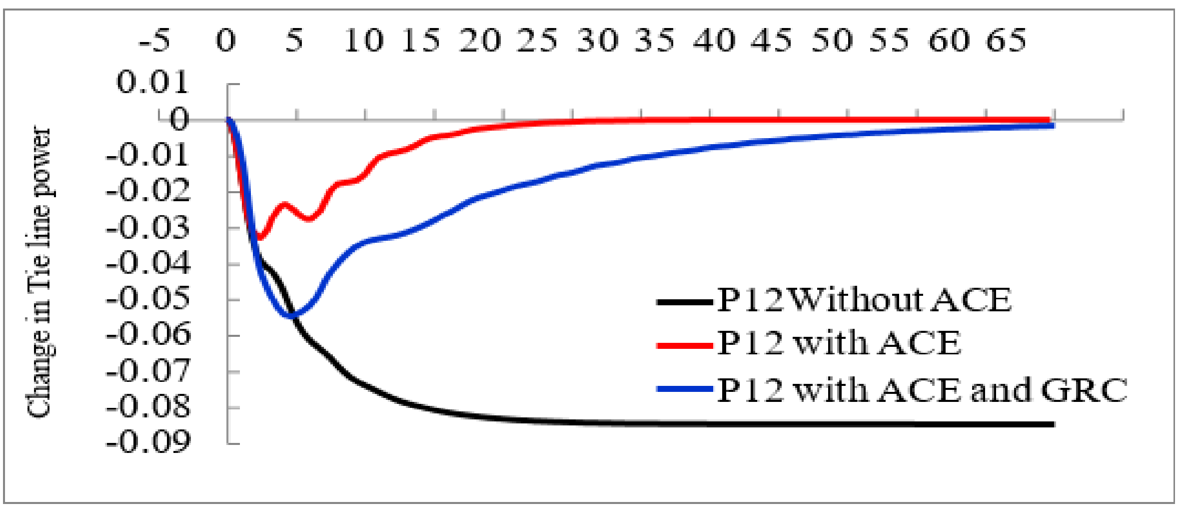


Figure 18: Comparisons between P12 with and without ACE

Table 4: Represent summary of figure 18

	Peak over shoot	S.S.Freq.	Settling time
Without ACE	-0.0844	-0.0844	21.245
With ACE	-0.0327	0.0	29.896
With GRC	-0.0546	0.0	48.220

Automatic Generation Control was implemented in the system under study in a deregulated environment. The effect of GRC is clearly distinct with large oscillations the system overshoots increase and more settling time.

The main reason to consider GRC is that the rapid power increase would draw out excessive steam from the boiler system to cause steam condensation due to adiabatic expansion. Since the temperature and pressure in the HP turbine are normally very high with some margin, it is expected that the steam condensation would not occur with about 20% steam flow change unless the boiler steam pressure itself does not drop below a certain level. Thus it is possible to increase generation power up to about 1.2 pu of normal power during the first tens of seconds. After the generation power has reached this marginal upper bound, the power increase of the turbine should be restricted by the GRC. GRC affecting large turbo generator is generally bounded by 0.1/min. As the constraint of the generator and that of control effort calculated in LFC are in direct proportions, GRC will be transformed into system control constraints.

VI. Conclusion

A simulation study of two area systems with automatic generation control is carried out with models developed in SIMULINK. The simulation of these systems has been carried out and results analyzed. The operation of two area systems with and without automatic voltage regulator are very well depicted through simulation models. The advantage of interconnection is best understood by comparing the results of two area systems. It can be seen that the oscillations due to the change in load in any area are damped down quickly because of tie-line power flow. It can also be observed that the dynamic response is mainly governed by the secondary loop and hence design criteria of which is extremely vital for efficient implementation.

The frequency of the system is dependent on real power output and is taken care of by ALFC. The terminal voltage of the system is dependent on the reactive power of the system and is taken care of by the AVR loop. The cross-coupling effects between the two loops are studied which is associated with low-frequency oscillations. It is clear from the results that the AVR loop is able to maintain the voltage and frequency deviations in the specified limits and the power system thus becomes more robust. The dynamic responses are further improved in terms of peak deviations and settling time.

References Références Referencias

1. H. Bevrani, Robust Power System Frequency Control. Cham, Switzerland: Springer International Publishing, 2014.
2. S. Saxena and Y. V. Hote, Load frequency control in power system via internal model control scheme and model-order reduction, IEEE Trans. Power Syst., vol. 28, no. 3, Aug. 2013, pp. 2749– 2757.
3. L. Jiang, W. Yao, Q. H. Wu, J. W. Wen, and S. J. Cheng, Delay-dependent stability for load frequency control with constant and time-varying delays, IEEE Trans. Power Syst., vol. 27, no. 2, May 2012, pp. 932–941.
4. G. Eason, B. Noble, and I. N. Sneddon, on certain integrals of Lipschitz-Hankel type involving products of Bessel functions, Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences, 247(935), 1955, pp.529-551.
5. D. Lathwal, P. Malik, S. Kumar, Analysis of Automatic Generation Control Two Area Network using ANN and Genetic Algorithm, International Journal of Science and Research (IJSR), India Online ISSN, 2013, pp. 2319-7064.
6. G. V. Hicks, B. Jeyasurya, P. Eng; An investigation of automatic generation control for an isolated transmission system, IEEE, 1997, pp.31-34.
7. P. Kundur, Power System Stability and Control, Mc Graw- Hill, New Delhi, 2002.
8. Dar, S. Z. N., 2017, May. Improved load frequency response in two area power system with battery energy storage. International Conference on Computing, Communication, and Automation (ICCCA), IEEE, 2017, pp. 977-981.
9. A. G. Ter-Gazarian, Energy Storage for Power Systems UK: IET Power and Energy Series, 2011.
10. F. D. Gonzalez, A. Sumper, O. G-Bellumunt, and R. V Robles, A review of energy storage technologies for wind power applications, Renewable, and Sustainable Energy Reviews, 2012 vol.16, no.4, pp2154-2171.
11. Jyothi, T. D., Lavanya, N., Shankar, C. B. and Sudhakar, T. An Intelligent Load Frequency Control for Two Area System. In 7th International Advance Computing Conference (IACC) IEEE, 2017, January, pp. 355-360.
12. Liu, F., Li, Y., Cao, Y., She, J. and Wu, M. A two-layer active disturbance rejection controller design for load frequency control of interconnected power system. IEEE Transactions on Power Systems, 2016, pp.3320-3321.
13. Ramjug-Ballgobin, R., Hassen, S. S. and Veerapen, S, Load frequency control of a nonlinear two-area power system. In 2015 International Conference on Computing, Communication and Security (ICCCS), IEEE, 2015, December, pp. 1-6.
14. AnilKumar, A. and Srikanth, N. V., October. Load frequency control for diverse sources of interconnected two area power system: An adaptive fuzzy approach. In 2016 International Conference on Control, Computing, Communication, and Materials (ICCCCM) IEEE, 2016, pp1-4.
15. Parmar, K. S., Majhi, S. and Kothari, D. P. Load frequency control of a realistic power system with multi-source power generation. International Journal

of Electrical Power & Energy Systems, 2012, pp.426-433.

16. Daneshfar, F. and Bevrani, H, Multiobjective design of load frequency control using genetic algorithms. International Journal of Electrical Power & Energy Systems, 2012, pp.257-263.
17. Nagarjuna, N. and Shankar, G.. Load frequency control of two area power system with AC-DC tie line using PSO optimized controller. In 2015 International Conference on Power and Advanced Control Engineering (ICPACE) IEEE, 2015, August, pp.227-231.
18. Kumari, N. and Jha, A. N. Frequency control of multi-area power system network using PSO based LQR. In 2014 6th IEEE Power India International Conference (PIICON) IEEE, 2014, December. pp. 1-6.
19. Chokpanyasuwan, C. Robot Fuzzy logic-PID Controller for Wind-Diesel Power System using Particle Swarm Optimization. In GMSARN International Conference on Sustainable Development: Issues and Prospects for the GMS, 2008.
20. Mallesham, G., Mishra, S. and Jha, A. N. Automatic generation control of microgrid using artificial intelligence techniques. In 2012 IEEE Power and Energy Society General Meeting, 2012, July, pp. 1-8.
21. Elmas, C., Deperlioglu, O., and Sayan, H. H. Adaptive fuzzy logic controller for DC-DC converters. Expert Systems with Applications, 2009, pp.1540-1548.
22. Parmar, K. S., Majhi, S. and Kothari, D. P. Load frequency control of a realistic power system with multi-source power generation. International Journal of Electrical Power & Energy Systems, 2012, pp.426-433.

Appendix

Table 5: Parameter of AGC model

Quantity	Area–I	Area–II
Governor Speed regulation	R1=0.051	R2=0.062
Frequency bias factors	D1= 0.62	D2=0.91
Base power	1000MVA	1000MVA
Governor time constant	$tg1$=0.2 sec	$tg2$=0.3 sec
Turbine time constant	$tT1$=0.5 sec	$tT2$=0.6 sec
Constant	K=1/2π	K=1/2π
Inertia constant	H1=5	H2=4
Nominal frequency	F1=50Hz	F2=50Hz
Load change	$\Delta PL1$=180MW	$\Delta PL2$=0MW

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 22 Issue 2 Version 1.0 Year 2022
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Integration of the Internet of Things in Service Management: Designing a Monitoring Device for the Elderly

By Flávio Fraga Vilela, Gabriel de Almeida Rebello Toledo & Rebeca Faria Tomaz

Sapucaí Valley University

Abstract- Controlling and monitoring the elderly is an arduous and imperative task with regard to their physical safety. To assist in this aforementioned control, the main objective of this project is to present a real prototype for monitoring the elderly. Therefore, this prototype can become a support tool for managers of nursing homes, hospitals, etc., as it enables a more precise control of these elderly people. The case study method was applied in this research through a qualitative exploratory approach. It was concluded that the prototype presented has great potential to assist the administration of care services for the elderly, whose importance is even greater in the current context of a growing number of elderly people in the brazilian population.

Keywords: *service management; elderly; internet of things; real prototype; monitoring device.*

GJRE-F Classification: *DDC Code: 362.60941 LCC Code: HV1481.G72*

INTEGRATIONOFTHEINTERNETOFTHINGSINSERVICEMANAGEMENTDESIGNINGAMONITORINGDEVICEFORTHEELDERLY

Strictly as per the compliance and regulations of:

Integration of the Internet of Things in Service Management: Designing a Monitoring Device for the Elderly

Flávio Fraga Vilela [α], Gabriel de Almeida Rebello Toledo [σ] & Rebeca Faria Tomaz [ρ]

Abstract- Controlling and monitoring the elderly is an arduous and imperative task with regard to their physical safety. To assist in this aforementioned control, the main objective of this project is to present a real prototype for monitoring the elderly. Therefore, this prototype can become a support tool for managers of nursing homes, hospitals, etc., as it enables a more precise control of these elderly people. The case study method was applied in this research through a qualitative exploratory approach. It was concluded that the prototype presented has great potential to assist the administration of care services for the elderly, whose importance is even greater in the current context of a growing number of elderly people in the brazilian population. Finally, it is expected that the real prototype, when in the future it is transformed into a technological product on the market, will be a plausible way to carry out the control of the elderly in an agile way. An increase in the physical safety of the elderly is also expected, as this device can contribute to a reduction in incidents of falls.

Keywords: service management; elderly; internet of things; real prototype; monitoring device.

I. Introduction

Service management needs robust tools to support it, as it is imperative that operations have to constantly work with a high level of efficiency (SLACK et al., 2002). It is important to highlight that the advent of Industry 4.0 brought six innovative pillars: manufacturing process technology, materials, data, predictive engineering, sustainability and resource sharing (KUSIAK, 2017). This last pillar must make an interface with the Internet of Things (IoT), which has the function of performing an agile intercommunication between several electronic devices, as well as between these and their users, through sensors and wireless connections (ASHTON, 2009). This aforementioned contextualization converges to a probable interface between service management and the aforementioned IoT. More specifically, in this article, service management will be more related to elderly care operations and the Industry 4.0 pillar that will be explored (resource sharing) concerns the intrinsic applications of the IOT. In view of the above, this article aims to present a real prototype that will have the purpose of real-time monitoring of the elderly who need more intense supervision. This prototype will be operated by an ESP8266EX microcontroller, coupled to an ultrasonic sensor, which installed in the doors or beds of elderly rooms will send a notification to an application installed on the nurse, caregiver or family member responsible for supervising the dependent elderly. This notification will have the information of which room or bed the assistance worker should go to to contain the elderly and prevent a probable accident, such as a fall, for example, which can bring severe consequences (KONRAD et al., 1999).

Author α σ ρ: UNIVERSIDADE DO VALE DO SAPUCAÍ
e-mail: flaviofvilela@univas.edu.br
Author σ: e-mail: gabrielreb7@gmail.com
Author ρ: e-mail: rebecafaria1501@gmail.com

II. Literature Review

a) *Aging of the Brazilian Population*

In recent decades, the aging of the world population has been marked by an increase in life expectancy and a reduction in birth and mortality rates in most countries. Thus, it was found an increase in the number of elderly people over 80 years old. Therefore, Brazil surpassed the mark of 30 million elderly people and reached 14% of the total population, with people aged 80 years or more (CECCON et al., 2021). In this advanced stage of age, the elderly is vulnerable from a social and physical and mental health point of view, with loss of autonomy and increased dependence being common (FREEDMAN & NICOLLE, 2020). It is also important to emphasize that there is a small portion of elderly people over 80 years old without their own income and who are unable to meet their basic needs, in addition to experiencing the serious health problems and physical and mental dependencies mentioned previously (MINAYO, 2012).

b) *Causes and Consequences of Elderly Falls*

According to the authors Coelho Fabrício et al. (2004), people of all ages are at risk of falling. However, for the elderly, they have a very relevant meaning, as they can lead to disability, injury and death. Studies carried out in the USA show that 30% of people over the age of 65 fall at least once a year, and 40% of them are over 80 years old. Furthermore, these studies show that 50% of elderly people who live in nursing homes or nursing homes have already suffered a fall (KANNUS et al., 1999). Statistical information indicates that fractures resulting from falls are responsible for approximately

70% of accidental deaths in people over 75 years, with the elderly having ten times more hospitalizations and eight times more deaths resulting from these falls (KONRAD et al., 1999).

c) Internet of Things

The term Internet of Things (IOT) was first introduced by Kevin Ashton in 1999 in the context of managing a supply chain (ASHTON, 2009). However, in the last decade, the definition has become more general, covering different application possibilities such as health, public services, security, etc. (SUNDMAEKER, 2010). Although the primary definition of "Things" has gained other semantics with the evolution of technology, the main objective of making a computer detect information without the aid of human intervention remains unchanged. In this context, an exponential evolution of the "Internet" into an interconnected network that collects information from the environment, interacts with the physical world (action, command, control) and uses existing standards to provide analytics, applications and communications services was observed. Using information from devices enabled by open wireless technology (Bluetooth, Wi-Fi) as well as embedded sensors, the Internet of Things has emerged from an incipient initial stage and is on the verge of transforming the current static internet into a fully integrated and future internet of the future. accessible (BUCKLEY, 2006).

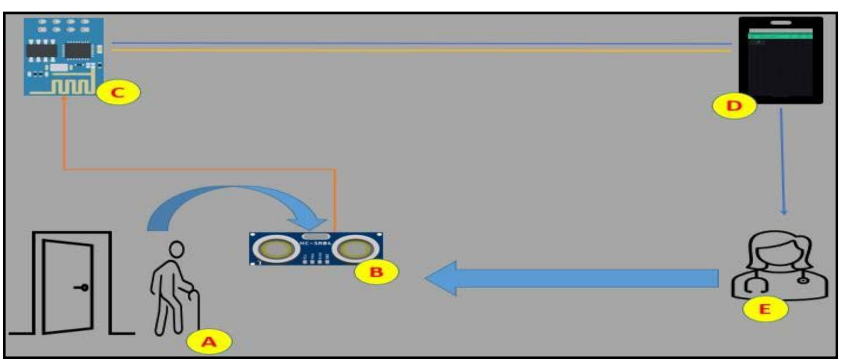
III. Research Methodology

This article has an applied nature, as its results have as its main function to solve some of the problems in the real world (TURRIONI and MELLO, 2012). In the context of this research, the problem is about the efficient real-time monitoring of elderly people. The applied nature seeks to generate essential knowledge and information to solve the problem of a real system that has, in this way, local truths and interests (GIL, 2002). Analyzing the historical data in the previously presented section "Aging of the Brazilian population" it is evident that the interests are also at the national level. As for the objectives, it can be said that the research is classified as exploratory, as it aims at discovering, finding, elucidating phenomena or explaining those that were not accepted despite being evident. Due to this exploratory character, a new product (electronic prototype) was conceived by creative impulse at the time the researchers were in field research. Finally, regarding the approach to the problem, the research is classified as qualitative, because in a real system analyzed, the case study method was applied.

IV. Method Development and Application

a) Application Context

The purpose of this real prototype is to present healthcare service managers with a device for monitoring elderly patients, whether in a hospital, residential or nursing home environment. The device has the function of notifying, through cell phone message, the nurse, caregiver or family member when the patient leaves their room or confinement area without proper monitoring. As shown Figure 1, the device can be installed, for example, close to an elderly person's bedroom door, either at home or in a hospital environment.



Source: The authors

Figure 1: Elderly monitoring overview

As soon as the latter leaves this room, the ultrasonic sensor recognizes the obstacle and immediately informs the person responsible, through cell phone message, about the undue movement of the monitored person. Also in this Figure 1, there is the following correspondence of the "letters": A – Elderly, B – Ultrasonic sensor, C – ESP8266, D – Application running on a smart phone, E – Nurse or family member.

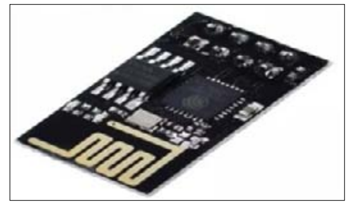
b) Technical Detail

The system is made up of hardware and software, with the ESP8266 being the main component of the hardware set. From software perspective, the system was developed in HTML5 and CSS, as this way an easy-to-understand "front-end" interface was created and executed. Therefore, the end user (caregiver) will receive the evasion message from the elderly person on their mobile device in an agile and reliable way. After the development of the virtual prototype and programming of the elderly monitoring device, it was possible to carry out the physical assembly of the project. The following is presented (Figure 2) how the real prototype looked, relative to its physical appearance. It is important to mention that the protection "case" was specifically designed in Autocad® to be used in this project.

Source: The authors

Figure 2: Real prototype for monitoring the elderly

The ESP8266 Module (Figure 3) is an open source prototyping platform designed with a dynamic and intuitive interface. This module, has a small size, and its cost is reasonably small compared to others, which have the capability of WiFi connectivity, in which it has an 802.11 b/g/n/e/i communication protocol, which allows a signal range up to 120 meters in an open place (ŠKRABA et al., 2016).



Source: The authors

Figure 3: Photo of the "protagonist" of the proposed device

c) Materials and Costs

Table 1 lists all components and their amounts that were used in the aforementioned device. The average price of each component is also shown in this table and it is evident that the costs are low at the expense of the device's application potential.

Table 1: Average price of materials used to assemble the elderly monitoring device

Component	Quantity	Average price ($)
ESP8266	1	7
LM2596 voltage regulator	1	3.5
Ultrasonic sensor	1	4
Seesaw key	1	3.5
DC power conector P4	1	0.5
9v source	1	3.5
Protection box (*case*)	1	3
Total		25

Source: The authors

V. Conclusion

The increase in life expectancy of the brazilian population, consequently, implies a growing number of elderly people in the country. This fact determines the emergence of new welfare demands that must be properly supplied and satisfied. Technologies that supplement stewardship and security actions within this context will have significant value to senior care administrators. For this reason, the actual prototype presented emerges as a relevant IoT technology. In relation to the present article conceived, it can be said that the proposed objective was satisfactorily achieved, as the real prototype for monitoring the elderly was presented in detail. In addition, it is essential to emphasize again the importance of the proposed IoT technology, as it quickly warns employees of nursing homes, hospitals, etc. that monitored elderly people are "leaving" their rooms without due care, enabling actions that prevent possible accidents, can be taken. Therefore, this technology enables greater control, monitoring and care for the elderly. Finally, this present work showed all the components used and their respective costs, making it clear that the low cost required for assembling the device will imply a market technological solution accessible to service managers, as soon as it is opportunely launched.

Acknowledgment

The authors of this research would like to thank the Fundação de Ensino do Vale do Sapucaí (FUVS) for all the support and encouragement to the research.

References Références Referencias

1. ASHTON, K. That "Internet of Things" thing, RFID jornal, 2009.
2. BUCKLEY, J. The internet of things: from RFID to the next-generation pervasive networked systems. New York. Auerbach Publications, 2006.
3. CECCON, R. F., VIEIRA, L. J. E. de S., BRASIL, C. C. P., SOARES, K. G., PORTES, V. de M., GARCIA JÚNIOR, C. A. S., SCHNEIDER, I. J. C., & CARIOCA, A. A. F. Aging and dependence in brazil: Sociodemographic and care characteristics of older adults and caregivers. 26(1), 17–26. Ciencia e Saude Coletiva. https://doi.org/10.1590/1413-81232020261.30352020, 2021.
4. COELHO FABRÍCIO, S. C., PARTEZANI RODRIGUES, R. A., & LOBO DA COSTA, M. Falls among older adults seen at a São Paulo State public hospital: Causes and consequences. 38(1), 93–99. Revista de Saude Publica. https://doi.org/10.1590/s0034-89102004000100013, 2004.
5. FREEDMAN, A., & NICOLLE, J. Social isolation and loneliness: The new geriatric giants Approach for primary care. 66(3), 176–182. Canadian Family Physician, 2020.
6. GIL, Antonio Carlos. Metodologia científica. v. 3. São Paulo, 2002.
7. KANNUS P, PARKKARI J, KOSKINEN S, NIEMI S, PALVANEN M, JÄRVINEN M, VUORI I. Fall – induced injuries and deaths among older adults. 281:1895-9. JAMA, 1999.
8. KONRAD H.R, GIRARDI M, HELFERT R. Balance and aging. Laryngoscope. 1999.
9. KUSIAK, A. "Smart Manufacturing." International Journal of Production Research. Published online. doi:10.1080/00207543.2017.1351644, 2017.
10. MINAYO, Maria Cecília de Souza. O envelhecimento da população brasileira e os desafios para o setor saúde. Rio de Janeiro, 2012.
11. ŠKRABA, A. et al. Streaming pulse data to the cloud with bluetooth LE or NODEMCU ESP8266. In: Mediterranean Conference on Embedded Computing, IEEE, 2016.
12. SLACK, N.; CHAMBLERS, S.; JOHNSTON, R. Administração da produção. 2ªed. São Paulo: Atlas, 2002.
13. SUNDMAEKER, H., GUILLEMIN, P., FRIESS, P. and WOELFFLÉ, S. Vision and Challenges for Realising the Internet of Things, Cluster of European Research Projects on the Internet of Things—CERP IoT, 2010.
14. TURRIONI, J. B.; MELLO, C. H. P. Metodologia de pesquisa em engenharia de produção: estratégias, métodos e técnicas para condução de pesquisas quantitativas e qualitativas. Programa de Pós-graduação em Engenharia de Produção, Universidade Federal de Itajubá, Itajubá, 2012.

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 22 Issue 2 Version 1.0 Year 2022
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Dielectric Loaded Directive Monopole Antenna

By Aladdin Assisi

Abstract- In this paper a new idea is proposed to convert an omnidirectional monopole antenna into a directive antenna. The idea consists in loading the antenna by a block of dielectric material that redirects the wave radiation in its direction. Different design cases have been numerically studied, simulated and optimized by CST Microwave Studio. In each case the same idea has been confirmed.

GJRE-F Classification: DDC Code: 004.16 LCC Code: QA76.592

Dielectric Loaded Directive Monopole Antenna

Aladdin Assisi

Abstract- **In this paper a new idea is proposed to convert an omnidirectional monopole antenna into a directive antenna. The idea consists in loading the antenna by a block of dielectric material that redirects the wave radiation in its direction. Different design cases have been numerically studied, simulated and optimized by CST Microwave Studio. In each case the same idea has been confirmed.**

I. Introduction

A monopole antenna is one half of a dipole antenna, mounted above a ground plane [33]. Applying the image theory, the electric and magnetic fields of a quarter wave monopole are those of a half wave dipole with one arm of the dipole replaced by the ground plane image. A quarter wave monopole antenna has a toroidal radiation pattern similar to its corresponding half wave dipole, with the exception that the peak direction is elevated from the horizontal plane by an angle that increases with the increase of the ground plane area (Figure 1).

In this paper, we propose a simple technique to convert a monopole antenna into a directive antenna by adding a simple dielectric material block in a certain direction with respect to the monoopole. Further studies will be required to evaluate the effects of different design parameters, such as the dielectric block dimensions, its separation from the monopole and its material on the antenna performance.

A directive monopole antenna can be used in ISM frequency bands for point-to-point communication without need to complex frequency hopping techniques that are currently used to minimize interference. The same dielecetric loading technique can be used to develop UWB directive monopole antennas for UWB radar and similar applications. Moreover, a directive monopole can represent a good array elemnt due to its simplicity of design and feeding.

II. Previous Research Work

Different references discussed dielectric loading effects on antenna performanc. Dielectric loading decreases the required antenna size for a given resonance frequency and in general increases the antenna bandwidth. It modifies the radiation pattern and increases antenna gain. S. Lotfollah discussed different effects of dielectric loading of antennas and different applications of dielectric loading structures to enhance antenna gain, size, matching and other performance parameters [32]. Heijun Jeong et al used a metamaterial absorber to control the radiation pattern of a monopole antenna by increasing its gain and reducing its back lobe [26]. A. MOUSAVI discussed in detail different aspects of flat dielectric radome design and its effects on the radiation pattern in his Msc. Thesis [31]. Several researchers discussed the use of superstrate layers to increase the BW and gain of microstrip patch antennas, such as K. Joshi [27], M. Elhefnawy [29], V. Saidulu [28], Kumar [30]. Ichirou Ida et al studied the efficiency-bandwidth product (EB) for small dielectric loaded antennas (DLAs) and its variation with dielectric constant [21]. T. Fortaki et al applied a rigorous full-wave mathematical analysis to investigate the effect of dielectric superstrate on resonance frequency and radiation pattern of rectangular microstrip patch antennas [23]. They proved that the resonance frequency decreases with the dielectric constant increase. O. Manoochehri et al designed an array of dielectric loaded helical monopoles and showed that by adding dielectric resonators, important parameters such as gain, side lobe level, impedance matching and axial ratio bandwidth have been improved simultaneously [16]. Detailed mathematical and experimental analyses for the refraction processes of electromagnetic waves in dielectric materials are done in the interesting chapter of “Dielectric Lens Antennas” by Carlos A. Fernandes et al, where the reader can understand why and how a dielectric body can change the direction of antenna radiation and affect its radiation pattern [24]. They differentiate between quasi-optical lenses with multi-wavelength dimensions and integrated lens antennas (ILA) with dimensions comparable to wavelength, which is our case, where FDTD analysis techniques are applicable. Design procedures and equations for different dielectric lenses are described in this reference. A research group applied those principles, designed an integrated lens patch antenna and studied the effect of different dielectric materials and lens dimensions on the radiation pattern [25].

I. Zivkovic loaded a monopole antenna uniformly from all directions by a cylindrical dielectric resonator to control its frequency response without affecting its omnidirectional radiation pattern [17]. Hongge Men et al did a similar frequency band control using a hemi-spherical dielectric resonator [18], while Ali A. Al-Azza et al extended the idea by using three dielectric resonators with different resonance frequencies [19]. Song et al proposed the use of liquid dielectrics to control the monopole antenna frequency response in a wide temperature range [20], while

Author: e-mail: aladdinassisi@gmail.com

Global Journal of Researches in Engineering (F) Volume XXII Issue II Version I Year 2022

Elizaveta Motovilova and Shao Ying Huang discussed in detail the performance of liquid monopole antennas. Heijun Jeong et al used a Metamaterial absorber to control the radiation pattern of a monopole antenna by increasing its gain and reducing its back lobe [26].

Hachi et al designed an UWB directional monopole antenna without dielectric loading. They implemented the UWB monopole on a flexible substrate and bent it on a cylindrical surface to get the directivity and enhance the radiation pattern [3].

None of the above mentioned and other available references discussed converting an omnidirectional monopole antenna into a directive antenna by dielectric loading. Therefore, the idea of this paper can be considered, so far, a new idea.

III. Dielectric Loading of a UHF Wire Monopole Antenna

The following figure shows the performance of a UHF monopole antenna resonating at 867 MHz. It can be clearly seen the symmetry of the electric flux lines and the radiation pattern around the monopole.

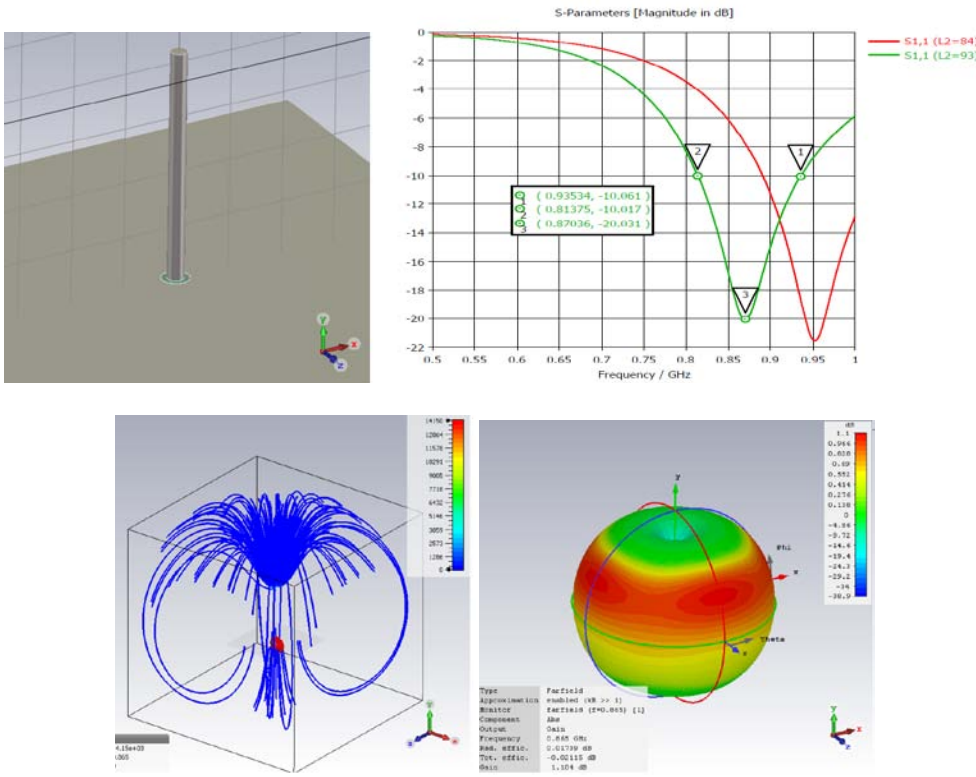
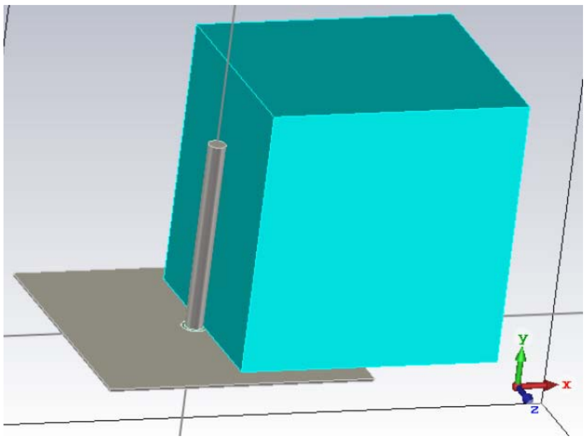


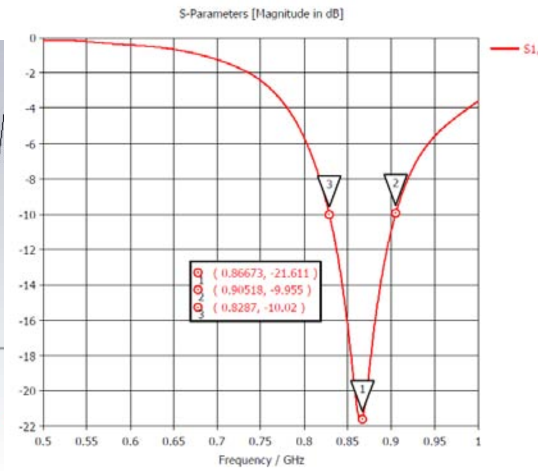
Figure 1: A UHF Monopole antenna and its pertformance

a. antenna design. b. S11 c. Electric Field flux d. Radiation pattern

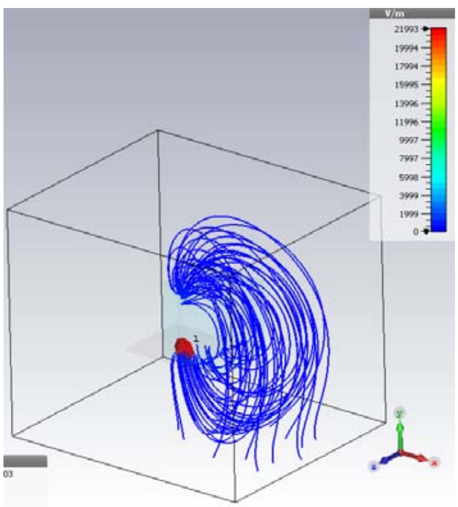
Let us put a block of dielectric material beside the monopole antenna and study its effect on the radiation pattern.



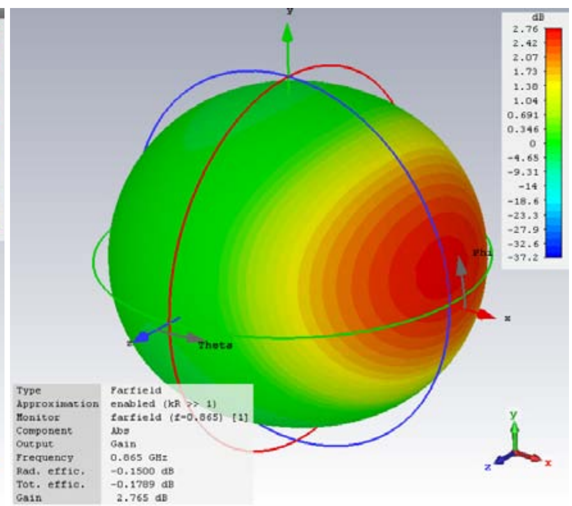
a. antenna design



b. S11



c. Electric Field flux



d. Radiation pattern

Figure 2: The same UHF Monopole antenna with dielectric loading and its pertformance

Comparing figures 1 and 2 we can recognize the following:

1. The monopole length required to resonate at 865 Mhz decreased due to the dieletric loading from 93mm to 71 mm.
2. The Q factor of the unloaded monopole antenna was 870/(935.5-813.7) = 7.158, while the Q of the loaded antenna is 866.73/(905.18–828.7) = 11.333.
3. The electric flux lines have been concentrated in the dielectric material instead of being uniformly distributed in all direction in the first case.
4. The monopole antenna radition pattern has been concentrated in the direction of the dielectric block to give a dirtective monopole antenna, instead of the symmetric toroidal pattern of the unloaded monopole antenna.
5. The antenna gain increased from 1.104 dB to 2.765 dB.
6. The radiation efficiency of the unloaded monopole antenna was $10^{-0.009535/10}$ = 99.78%.
7. The radiation efficiency of the loaded monopole antenna became $10^{-0.15/10}$ = 96.6%.
8. The total efficiency of the unloaded monopole antenna was $10^{-0.03636/10}$ = 99.166%.
9. The total efficiency of the loaded monopole antenna became $10^{-0.1789/10}$ = 95.964%.
10. The dielectric loading caused a minor decrease in the antenna efficiency.

The differences between the omnidirectional monopole antenna and the dielectric loaded directive monopole antenna can be summarized in the following table.

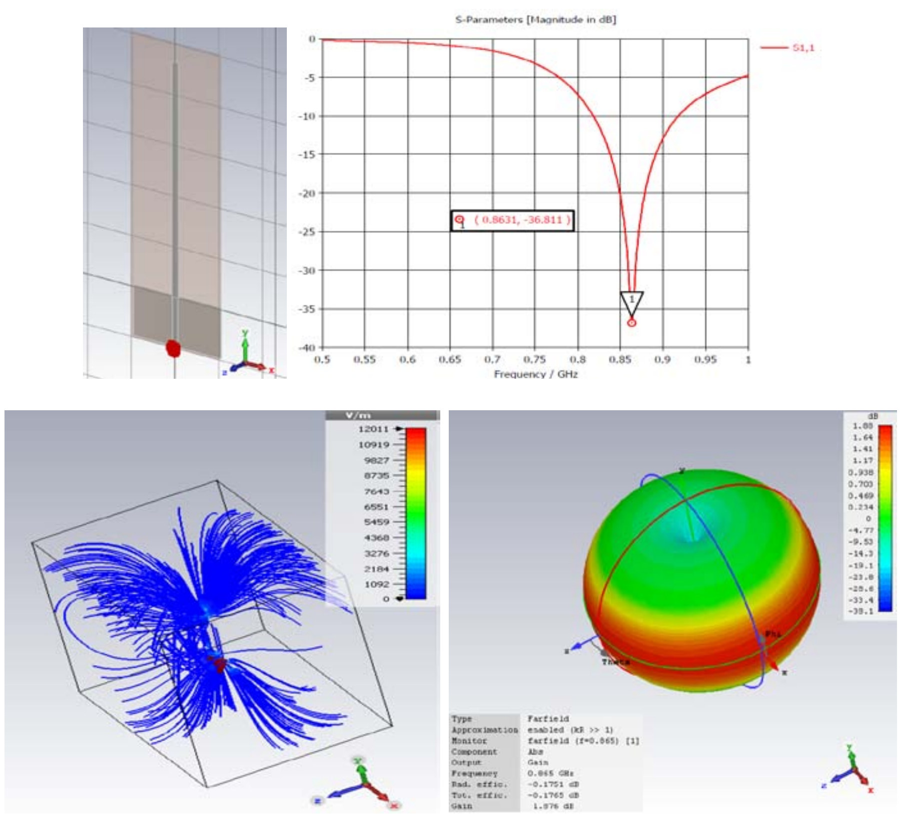
Global Journal of Researches in Engineering (F) Volume XXII Issue II Version I Year 2022

Table 1

Performance parameters	Units	Omnidirectional monopole antenna	Directive monopole antenna	Notes
Resonator length	mm	93	71	*Shorter resonator*
Q	-	7.158	11.333	*Higher quality*
Gain	dB	1.104	2.765	*Gigher gain*
Radiation efficiency	%	99.78	96.6	*Minor decrease Due to dielectric loading*
Total efficiency	%	99.166	95.964	

IV. Dielectric Loading of a UHF Printed Monopole Antenna

To demonstrate the applicability of the same idea on printed monopole antennas and to get more insight in the performance of directive printed monopole antennas, another UHF model has been simulated on the popular 1.6mm thick FR4 substrate.



a. antenna design. b. S11 c. Electric Field flux d. Radiation pattern

Figure 3: A printed UHF Monopole Antenna on FR4 and its pertformance

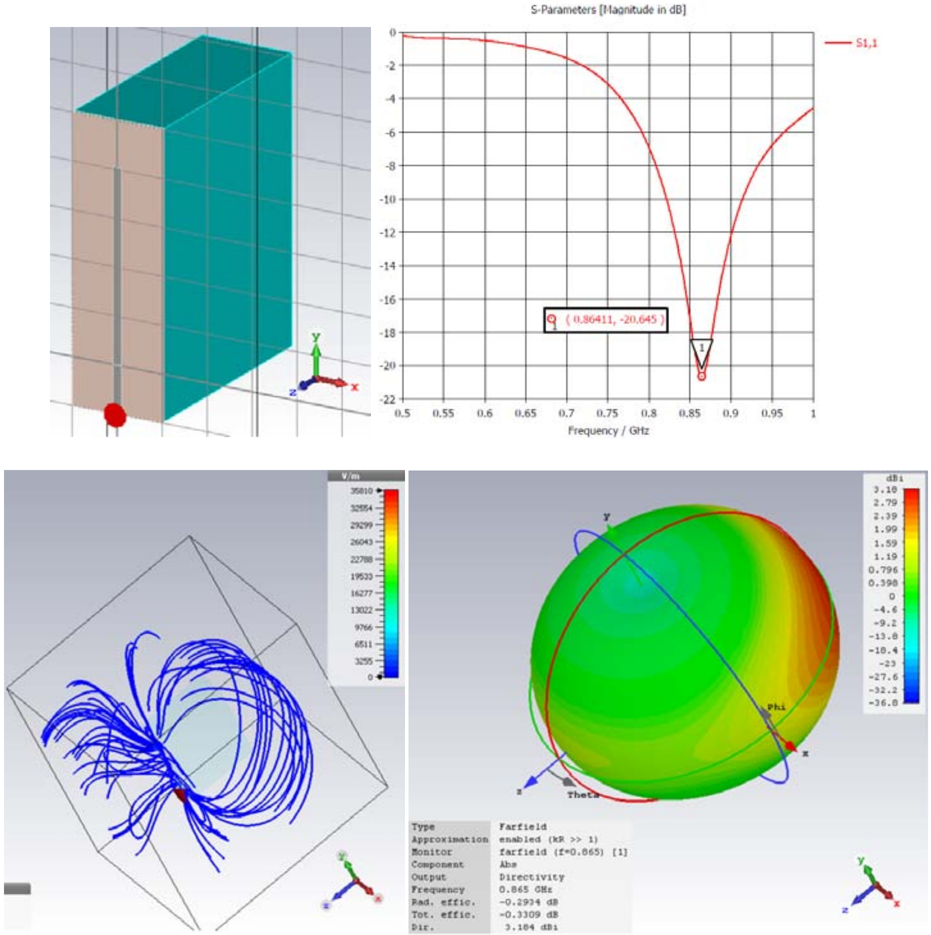


Figure 4: The same UHF Printed Monopole Antenna with dielectric loading

Comparing figures 3 and 4 we can build the following table.

Table 2

Performance parameters	Units	Omnidirectional monopole antenna	Directive monopole antenna	Notes
Resonator length	mm	93	76	*Shorter resonator*
Q	-	8.665	9.329	*Higher quality*
Gain	dB	1.876	3.184	*Gigher gain*
Radiation efficiency	%	96.048	93.467	*Minor decrease Due to dielectric loading*
Total efficiency	%	96.017	92.664	

V. Putting the Dielectric Block in the Opposite Direction

If we put the dielectric block in the oppsite direction, logically the beam will be steered by 180 degrees as shown in the following figure.

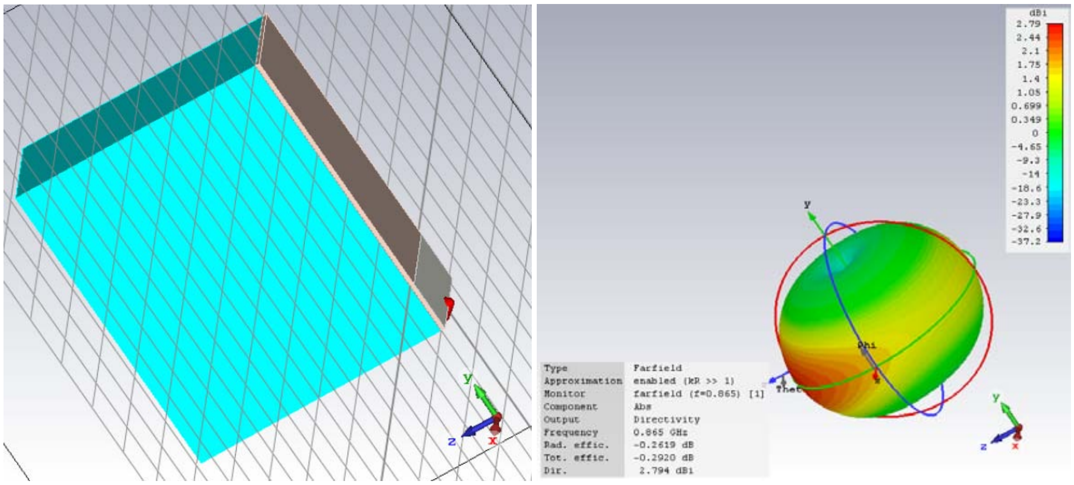


Figure 5: Dielectric in the oppsite direction

VI. Dielectric Loading of a 2.4 GHz Printed Monopole Antenna

The 2.4 GHz ISM band is one of the most utilized and crowded frequency bands; due to the existance of many commercial communication and control systems, such as cordless telephone, baby monitors, WiFi standards 802.11b, 802.11g and 802.11n, ZigBee/IEEE 802.15.4-based wireless data networks, Bluetooth, Bluetooth_LE, wireless microphones, headphones and speakers and others. Due to this over utilization of this frequency band, interference probabilities are very high. This causes the system designers to apply complex frequency hopping, data encription, error detection and correction techniques. Moreover, device pairing in Bluetooth systems requires complex protocols that need long times to secure pairing and avoid interference.

If we ensure a directive path between the transmitter and the receiver, interference probabilities will decrease and Bluetooth pairing processes can be simpler and more secure. In most cases, frequency hopping will be less mandatory.

The following figure shows the performance of a 2.4 GHz printed monopole antenna covering the frequency band 2.4 to 2.5 GHz. It can be clearly seen the symmetry of the electric flux lines and the radiation pattern around the monopole.

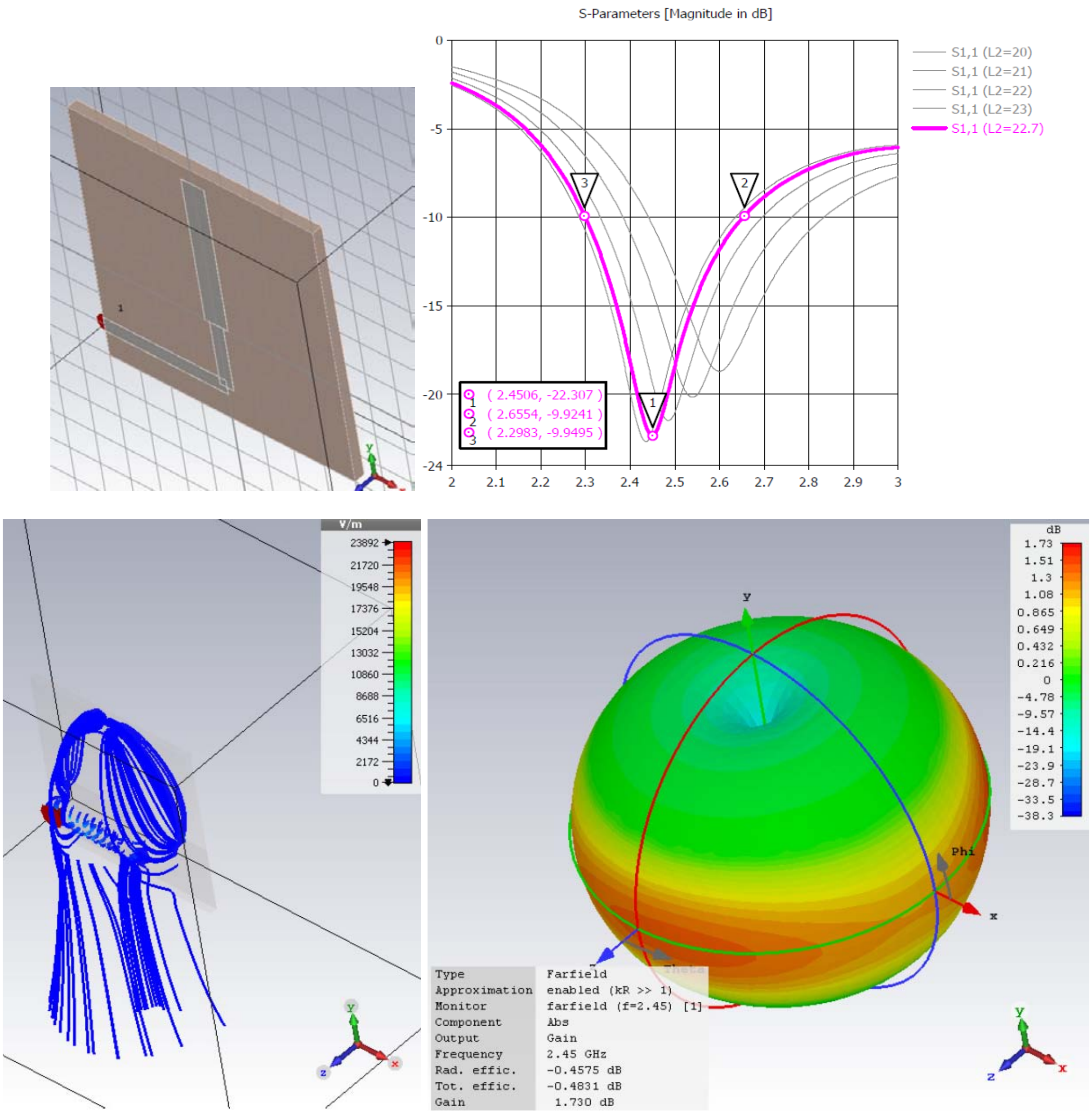


Figure 6: A printed 2.4 GHz Monopole Antenna on FR4 and its pertformance

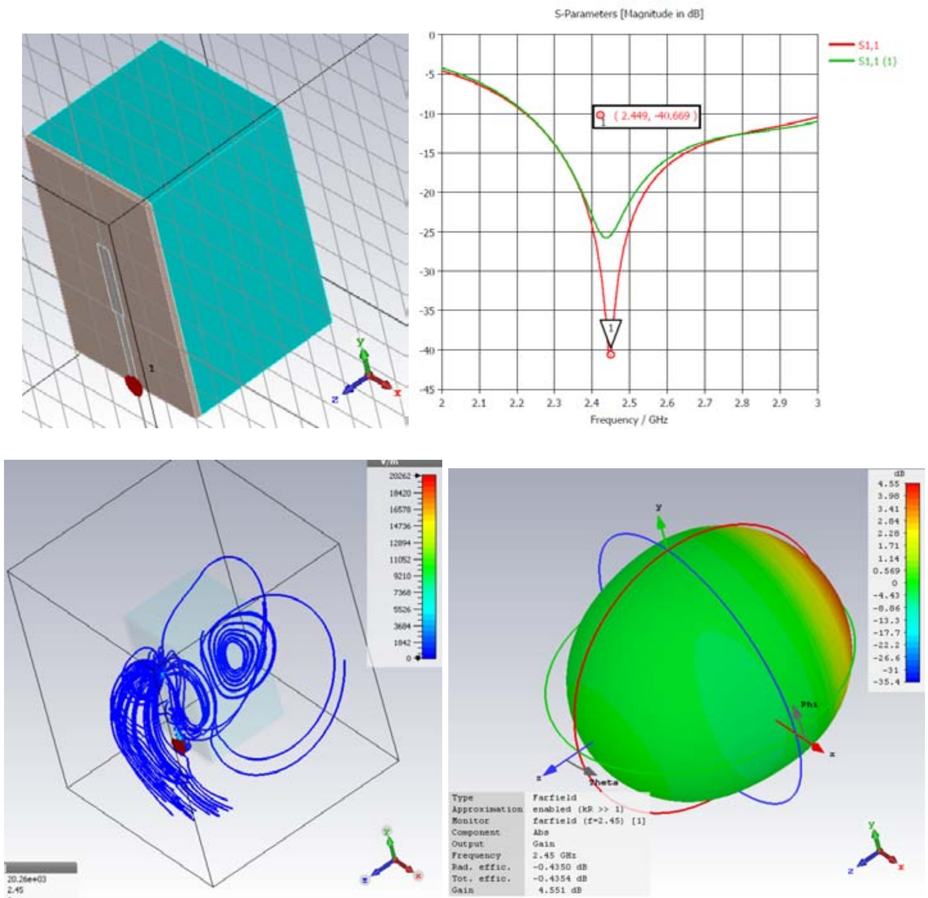


Figure 7: The same 2.4 GHz Printed Monopole Antenna with dielectric loading

Comparing figures 6 and 7 we can build the following table.

From this table we can conclude that the dielectric loading needs a shorter resonator, increases the BW and the efficiency. The directive gain reaches more than 4.5 dB.

Table 3

Performance parameters	Units	Omnidirectional monopole antenna	Directive monopole antenna	Notes
Resonator length	mm	22.7	20.2	*Shorter resonator*
Q	-	6.8625	3.274	*Wider BW*
Gain	dB	1.73	4.55	*Much Gigher gain*
Radiation efficiency	%	90	90.469	*Higher efficieny*
Total efficiency	%	89.47	90.46	

VII. Dielectric Materials to be Used

In the above models, a dielectric material with $\varepsilon_r = 3.1$ and $\tan(\delta) = 0.007$ was assumed. These are typical electrical parameters of composite materials used in 3D printers, such as PLA, ABS and PET [4, 5 and 6]. Such materials are easily found in the market at economical costs. In this section we shall breifly study the electrical parameters of common dielectric materials used in 3D printers.

Veselý et al measured the relative permittivity of dielectrics by measuring the capacitance of a circular parallel plate condenser with diameter d and thickness w of the material under test [4] and applying the simple formula:

$$\varepsilon_r = \frac{C \cdot w}{\varepsilon_0 \cdot (\pi \cdot \frac{d^2}{4})}$$

Unfortunately, different measuring methods gave different results for the same materials, even by the same reasurcher. Naturally, other references gave different results. Such as those of Boussatour et al [6]. However, the range of variation of dielectric constants of those materials is between 2 and 3.5, and the dissipation factor ranges between 0.001 and 0.022.

VIII. Conclusion

- Quarter wave monopole is an omnidirectional antenna with omnidirectional radiation pattern. It can be changed into a directive antenna by dielectric loading.
- The dielectric material block concentrates the electric field of the antenna and reradiates the waves in its direction increasing the antenna gain. The effects of dielectric loading increase with its relative permittivity [15].
- The dielectric loading shortens the required monopole length and enhances some of its performance parameters.
- The dielectric block can be made of commercially available materials such as those used in 3D printers, whoes dielectric constants range between 2 and 3.5. The exact dielectric constants of those materials are still subject to trials for accurate measurement.
- Three cases have been studied in this paper; an UHF wire monopole, an UHF printed monopole and a 2.4 GHz printed monopole. Further studies are still required to evaluate and optimize UWB directive monopole antennas and directive monopole arrays.
- Further investigations should be done to determine the minimum required dimensions of the dielectric block to give a certain radiation pattern in every frequency band.
- Further research work should be done to study the design of directive UWB monopole antennas and antenna arrays with directive monopole elements.

References Références Referencias

1. C. A. Balanis, "**Antenna Theory, Analysis and Design**", third edition, J. Wiley and sons, 2005.
2. A K M Shafaat Ali, and Irfan Ahmed, "**Electrical characterization of glass fiber reinforced polymer (GFRP) composites for future metasurface antenna applications"**, *Materials Research Express, Volume 8, Number 6, 2021.*
3. Hachi, Asmae & Lebbar, Hassan & Himdi, M. & Kurup, Dhanesh. (2019), "**Directional Ultra-Wideband Monopole Antennas**". *Far East Journal of Electronics and Communications. 21. 53-65. 10.17654/EC021120053.*
4. Petr Veselý et al, "**Study of electrical properties of 3D printed objects",** *Poster, World Conference on Medical Physics and Biomedical Engineering, PRAGUE 2018.*
5. **P. Veselý** *et al, "***Evaluation of dielectric properties of 3D printed objects based on printing resolution",** *5th International Conference Recent Trends in Structural Materials. 2019.*
6. G. Boussatour, P.- Cresson, B. Genestie, N. Joly, and T. Lasri, '**Characterization of biodegradable and biosourced polylactic acid (PLA) substrate in a wide frequency range (0,5–26 GHz)***', in 2017 IEEE MTT-S International Microwave Workshop Series on Advanced Materials and Processes for RF and THz Applications (IMWS-AMP), 2017, pp. 1–3.*
7. Naito, Kimiyoshi & Kagawa, Yutaka & Utsuno, Seishi & Naganuma, Tamaki & Kurihara, Kanshi. (2009). "**Dielectric properties of woven fabric glass fiber reinforced polymer-matrix composites in the THz frequency range**". *Composites Science and Technology. 69. 2027-2029. 10.1016/j.compscitech. 2009.04.001.*
8. https://www.rfcafe.com/references/electrical/dielectric-constants-strengths.htm
9. A K M Shafaat Ali and Irfan Ahmed, "**Electrical characterization of glass fiber reinforced polymer (GFRP) composites for future metasurface antenna applications"** *2021 Mater.Res. Express 8 065201.*
10. P. Veselý et al 2018 IOP Conf. **Ser., "Evaluation of dielectric properties of 3D printed objects based on printing resolution**": Mater. Sci. Eng. 461 012091.
11. Praveen D et al, **"Dielectric studies of Graphene and Glass Fiber reinforced composites**", *IOP Conf. Series: Materials Science and Engineering* ***310*** *(2018) 012153 doi:10.1088/1757-899X/310/1/012153.*
12. K. Praveen Kumar et al, "**The effect of dielectric permittivity on radiation characteristics of co-axially feed rectangular patch antenna: Design & Analysis**", ***International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 2, February 2013.***
13. D. Pathania and D. Singh, **"A review on electrical properties of fiber reinforced polymer composites**", *International Journal of Theoretical & Applied Sciences,* **1**(2): 34-37(2009) **ISSN: 0975-1718.**
14. Khalil H. Sayidmarie and Yasser A. Fadhel, "**Design Aspects of UWB Printed Elliptical Monopole Antenna with Impedance Matching**", *2012 Loughborough Antennas & Propagation Conference, 12-13 November 2012, Loughborough, UK.*
15. Aladdin Assisi, "**A Design Study of Printed Moxon Antenna**", *London Journal of Research in Science: Natural and Formal Volume 21 | Issue 1 | Compilation 1.0, 2021.*
16. Omid Manoochehri, Seyyedpayam Abbasiniazare, and Keyvan Forooraghi, "**Design of a 232 Tapered Dielectric-Loaded Helical Antenna Array for Inmarsat-M Satellite System***", MICROWAVE AND OPTICAL TECHNOLOGY LETTERS/Vol. 55, No. 11, November 2013.*
17. I. Zivkovic, "**Dielectric Loading for Bandwidth Enhancement of Ultra-Wide Band Wire Monopole**

Antenna", *Progress In Electromagnetics Research C, Vol. 30, 241-252, 2012.*

18. Hongge Men et al, "**Hemispherical Dielectric Loaded Monopole Antenna**", *2015 Loughborough Antennas & Propagation Conference (LAPC).*
19. Ali A. Al-Azza et al, "**Three-Stacked Dielectric Ring Resonator Loaded Hybrid Monopole Antenna for Improved Ultrawide Bandwidth**", *Applied Computational Electromagnetics Society (Vol. 35, pp. 545–550). Sep 2020*.
20. Song, C, Bennett, EL, Xiao, J, Hua, Q, Xing, L & Huang, Y 2019, "**Compact Ultra-Wideband Monopole Antennas Using Novel Liquid Loading Materials**", *IEEE Access*, vol. 7, pp. 49039-49047, 2019.
21. Ichirou Ida et al, "**Dependence of the efficiency-bandwidth product of small dielectric loaded antennas on the permittivity**", *PROCEEDINGS OF ISAP2000, FUKUOKA, JAPAN, Jan 2000*.
22. Elizaveta Motovilova and Shao Ying Huang, "**A Review on Reconfigurable Liquid Dielectric Antennas**", *Materials **2020**, 13, 1863; doi:10.3390/ ma13081863.*
23. T. Fortaki et al, "**Evaluation of the Radiation of Rectangular Microstrip Antenna Covered with a Dielectric Layer**", *SETIT 2007, 4th International Conference: Sciences of Electronic, Technologies of Information and Telecommunications, March 25-29, 2007 – TUNISIA.*
24. Fernandes CA, Lima EB, Costa JR. "**Dielectric lens antennas**". In: Chen Z, ed. **Handbook of Antenna Technologies**. *Singapore: Springer; 2015.*
25. Kamran Saleem M, Xie M, Alkanhal MAS and Saadi M., "**Effect of dielectric materials on integrated lens antenna for millimeter wave applications**", *Microw Opt Technol Lett. 2019;1–5. https://doi.org/10.1002/ mop.31676.*
26. Heijun Jeong et al, "**Gain-Enhanced Metamaterial Absorber-Loaded Monopole Antenna for Reduced Radar Cross-Section and Back Radiation**", *Materials **2020**, 13, 1247; doi:10.3390/ma13051247 www.md pi.com/journal/materials.*
27. K. Joshi et al, "**Superstrate Layer in Patch Antenna – A Review**", *International Journal of Latest Trends and Technology (IJLTT), Volume 6 Issue 2, 2015.*
28. V. Saidulu, "**Dielectric Cover Layer Thickness Effect on Circular Microstrip Antenna Parameters**", *International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-9 Issue-6, March 2021.*
29. M. Y. Elhefnawy et al, "**Improving the Performance of a Planar UWB Antenna by Adding Cover Layers**", *life science Journal, 2019.*
30. K. Praveen Kumar et al, "**The effect of dielectric permittivity on radiation characteristics of co-axially feed rectangular patch antenna: Design & Analysis**", *International Journal of Advanced Research in Computer and Communication Engineering, Vol. 2, Issue 2, February 2013.*
31. ATEFEH MOUSAVI, "**Evaluation of radome effects on the radiation properties for a 24 GHz phased array antenna**", *Department of Electrical and Information Technology Lund University, June 26, 2020*.
32. Shafai Lotfollah, "**Dielectric Loaded Antennas**", *In book: Encyclopedia of RF and Microwave Engineering, DOI:10.1002/0471654507.eme070, April 2005.*
33. https://www.antenna-theory.com/antennas/monopo le.php

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 22 Issue 2 Version 1.0 Year 2022
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

A Review on Smart Car Parking System

By Rani Astya, Soni Jain, Sukriti Sachan & Aish Aggarwal
Sharda University

Abstract- Nowadays vehicle parking has become an important issue and the need is increasing day by day. Growing population in metro cities is leading to huge vehicle density, the problems for car parking has become an unending question. In India we are still using a manual vehicle parking system and that is why we are struggling with the waste of time and fuel problem. When we need to park our car, we need to park our car. The conventional parking systems do not have any intelligent monitoring arrangement; causing wastage of time to find the slot and traffic on the way to park. Conditions are worse when there are multiple lanes and multiple parking slots. In this paper, we present an incisive overview of different methods and tools used in implementation of smart parking systems.

Keywords: *vehicle detection, tracking, parking, sensors, cars.*

GJRE-F Classification: *DDC Code: 725.38 LCC Code: TL175*

AREVIEWONSMARTCARPARKINGSYSTEM

Strictly as per the compliance and regulations of:

A Review on Smart Car Parking System

Rani Astya [α], Soni Jain [σ], Sukriti Sachan [ρ] & Aish Aggarwal [ω]

Abstract- Nowadays vehicle parking has become an important issue and the need is increasing day by day. Growing population in metro cities is leading to huge vehicle density, the problems for car parking has become an unending question. In India we are still using a manual vehicle parking system and that is why we are struggling with the waste of time and fuel problem. When we need to park our car, we need to park our car. The conventional parking systems do not have any intelligent monitoring arrangement; causing wastage of time to find the slot and traffic on the way to park. Conditions are worse when there are multiple lanes and multiple parking slots. In this paper, we present an incisive overview of different methods and tools used in implementation of smart parking systems. There are different approaches being researched upon by people including using IOT, different sensors, cloud or deep learning as well and all the different approaches being used by people have been mentioned in this paper. The paper presents a comparison of all the pros and cons for the approaches being presented by authors in different research papers.

Keywords: vehicle detection, tracking, parking, sensors, cars.

I. Introduction

In recent years, the world's population has increased, and hence the complexity of transportation has increased dramatically. With the increase in use of vehicles in cities, the problem of car parking has been raised. Smart parking is a parking strategy that combines technology and human innovation, aiming to use as few resources as possible, such as fuel, time and space, to park vehicles faster, easier and more densely during most of the time they are idle. The general approach to finding a parking spot is to aimlessly go around and drive until a free spot is found. This system would reduce empty parking space searching time. The user will automatically find the parking space by identifying entry and exit of the cars using the camera. It reduces the time wastage in finding the vacant parking lot for vehicles and also reduces the wastage of fuel Consumed while driving the cars or vehicles in the parking lot for finding the empty space to park vehicles. Time and fuel are wasted unnecessarily because the destination is unknown. A smart car parking system gives a visual result that reflects available parking space, rather than aimless driving. The smart car parking systems being introduced till now have presented multiple approaches and are focused on solving the problems being faced by people in their daily lives. The focal point of all the authors has always been to present the best they can. The different approaches introduced by them have been presented in this paper.

Author α: Guide, Department of Computer Science and Engineering, School of Engineering and Technology, Sharda University, Greater Noida, Uttar Pradesh. e-mail: astyarani@gmail.com

Author σ ρ Ѡ: Student, Department of Computer Science and Engineering, School of Engineering and Technology, Sharda University, Greater Noida, Uttar Pradesh.

II. Internet of Things based Approach

The approach proposed by Prof. Denis along with Akshat and Vipul Jigree in [1] has basically focused on the multi-storied parking areas along with the concept of Energy Conservation and Management. As per the approach, the vacant spaces will be depicted through lamps and the occupied ones will be virtually stored on the cloud which can further be accessed by the central system. The system consists of various components. It consists of a parking sensor working on Passive Infrared and Ultrasonic technology thereby detecting any human or vehicle presence. In order to update the vacancy status of the area, the data will be given via RJ25 interface, the moment the car will occupy the space it's status will be updated as 'Occupied' in the system's GUI. Following the Energy Conservation, after a while of the car being parked the lights will be dimmed, which will get illuminated when the owner returns to the vehicle. The system will have data depicted for different floors for multi-storied systems. An external source of Zigbee has been used in order to get the vehicle as well as owner's data being stored.

The architecture presented in this paper has been divided into three major constituents, the device which can be considered as any device assembling the data as per the segregation; edge server is the one being deployed in a LAN network connecting with the communication channels and the cloud server connecting the controller in order to manage the energy, also it provides the requirements needed for computation. Also, the software model is being segregated into several different layers starting from related to sensing generating the information and maintaining the connection, followed by the networking related to the transfer of data among the devices as well as server. The layers also include the awareness regarding the environment including the processing, configuration and the optimization as well. The last layer includes the features related to the management and the network. The proposed system focuses on saving time and power. Also the proposed system provides an enough spacing facility in order to avoid the unstructured layout and to manage a maintained approach as well.

a) RFID & LCD based

The approach proposed in [2], focused on providing a user friendly and reliable parking system. According to the approach the vehicle that needs to be parked will be provided with a unique id. In this system, as soon as the vehicle enters, the driver needs to deboard and look for the parking availability. Then the user will need to select any one slot of his choice from the available ones so that with the help of mechanical structure the car can be parked at that slot. The vehicle will trace the path to the slot as well. The time when the vehicle will be parked it's details will be sent to the Car Control Unit and further the status will be updated on the LCD as well.

The system follows some major steps and uses some components in order to follow the algorithm of the approach. The user's details will be checked and verified at the Verification Unit and thereby will be provided with a smart card. Also for security, a password will be given as well. There will be a floor indicator depicting the status if a slot is available or not. The LCD will show the details of the occupied and left spaces as well. The system will consist of some hardware and software components. LCD, DC Motor, RFID tag will be used for the hardware.

Also microcontrollers will be used so that the program memory can be re-programmed in the system. Also the RFID will be used as the user will receive a distinct ID, by which movement can be identified. In order to support different designs of microcontroller, Proteus 8 will be used.

The paper[15] presented the concept of having multiple sensors detecting vehicles and further sending the data to the server. The system involves steps like checking for the free slots, getting the fastest route as well. Further the user will be getting a different QR Code while parking at the slot. The user will receive the details regarding the booking and parking on the registered phone numbers and further they'll be getting the access via RFID Card and Token. The system involves multiple modules, QR Code Module, RFID Module, GSM Module, server, power, motor etc connected via the Arduino Mega. The requirements for the system are Arduino mega, IR Sensors, Servo Motor, RFID, GSM and QR Code Module's. The system starts with logging in to the application, followed by the process of accessing via RFID or Token thereby receiving the QR Code and so users can further book the slots and work towards the navigation process as well.

b) NB-IOT based

Praveen & Harini in [5] has discussed the NB-IOT technology for the approach. The NB-IOT Technology provides various benefits and provides efficient solutions among the communication devices. The technology ensures a greater coverage of the network and requires enough signal penetration and is slightly variant as compared to rest of the technologies in use whether the radio frequency one or any third party technology. The Narrowband technology facilitates enough maintenance and a great reliability with better quality. Also, it provides a better data generation.

The approach is to provide a mobile application working with the help of NB-IoT technology. The user will be needed to get registered on the application with all the details, after logging in one can check the availability of the slot, and the user can book the slot. The available and unavailable slots will be displayed with different colors to the user and the timer will be started on parking, if the timer exceeds a notification will be sent to the user. The system consists of various hardware equipment like sensors, which allows it to detect the presence of vehicles. The status will be transferred to the central server which then processes the payment transaction as well. Parking meter will specifically for the payment procedure as per the time for which the vehicle is parked. Further, the central server will be used for communication with all the peripherals being used in the system. Also, the system consists of a Buzzer, which will be having a number of sensors connected to the server sending a warning in the form of continuous beep sound.

c) GSM based

The approach presented in [3] presents a concept of transfer of data through a network without human interactions with the help of IoT. IoT provides wireless technologies at an affordable price along with transferring data to the cloud. The approach is focused on using sensors thereby analysing and processing the data, further the data will be transmitted to the transmitters in the form of output. The useful data then be extracted and will be further given to Arduino. The system also consists of a servo motor and a GSM module, which will then be instructed with Arduino. The RFID card is provided to the user on entrance which then can be scanned by user module keeping the privacy and security constraints. Also RFID enables the user to detect the availability of the spaces and give the notification to the registered number as well.

The system is basically segregated into three modules, first one working upon the parking area with the help of Arduino and Infrared Sensors. The second one will be working with the cloud web series that will be acting as a mediator between the area and the user. As soon as the changes happen in the area, the cloud will also get updated for the same. Then the last section is basically the one presented to the user. Users will be receiving the notification regarding free slots via SMS. The user can interact with the cloud as well as the parking area. The user will be notified for all occupied as well as the free spaces. The user will be given an RFID card, which will be required every time while an entry having details of the user will be scanned and thereby details being transferred. Then as per the approach the sensors will check for the available spaces and the user will be notified for the same. The activity of the user then will be stored in the cloud.

The idea of a miniature model of an automated car parking system proposed in [6] by Bonde. D.J Shende, Kedari, Gaikwad, K.S & Bhokre focused on developing a system providing an automated parking system. The system proposed a LCD for displaying the number of cars parked and the free slots for more cars to be parked. As the user enters the parking area, he/she would deboard the vehicle and with the help of application the command of car to be parked will be given, the car would be following the path towards the parking space further following the path towards the free slot. The data for the same will be updated on the LCD automatically. The proposed model will be working on four major modules, the first one will be the LCD interfaced with microcontroller, GSM interfacing the microcontroller, followed by the interfacing of microcontroller with RF module and Android application. The whole methodology has been divided into two, an architecture for cars and another for the parking area. The android application will be helping in order to command the parking system, and the system installed in the car will further look for the movement of the car following the commands. The android application will be connected with the GSM module, further working with microcontrollers. The microcontroller will update the details on the LCD as well as connect with the RF module of the parking system which will be further connected with the RF module of the car. The RF module in turn will be connected to the sensors via the microcontroller and hence working with the engine. The data received from the application or the microcontroller will be stored in the buffer of GSM. Also the Rf module has been used in order to maintain an inter microcontroller communication. The mathematical model used in the system will be expressed in two functions, one for searching the free space and other to retrieve the car from the system.

C:P*I*ES………………………[6]{equation 1, where C is the “Park My Car” function, implementing sequential search, I denoting the set of slots, ES giving the empty slots and P will be depicting the set of parking space}

GS*T………………………[6]{equation 2, where G will be denoting the “Get My Car” function, S and T be denoting the strip numbers in the parking area and the direction whether left or right respectively}

III. Cloud-of-Things based Approach

The approach proposed by [4] has been focusing on locating a free parking slot in order to reduce the time of the user. The system proposes, collects and filters out the raw data further extracting features by applying filtering and fusion techniques in order to prevent the transmission of extra data over the network. The transformed data will further be sent on cloud in order to process and evaluate using the ML algorithms.

The proposed system consists of sensor nodes, the indoor system is in the basement area and that of outdoor one is outside, other than that there are microcontroller devices. Cloud will act as an intermediary factor amongst the car parking and the application. The major objective of this system is to collect the sensor’s data in order to detect the presence of vehicles in parking slots with the help of WSN. In order to handle the sensor generated information, a middleware architecture will be needed. The sensors will be assigned to the parking system of indoor as well as outdoor for gathering information which will further be evaluated and processed using the IoT devices. The processed information will further be processed by the ML algorithms. Android application will help in order to locate the closest car parking slots further users can avail the nearest vacant slot. Bluetooth will be further used in order to achieve communication amongst the sensors and microcontrollers. The HTTP protocol fulfills the purpose of establishing communication between users and the cloud.

The automated parking system proposed in [7] has used the RFID card for storing information of every vehicle entering in the parking space. The system has been designed as such to calculate the time from entry to exit, and consists of software as well as the hardware equipment. Also, the system will have LED displaying the available slots and the parked ones as well. The RFID will be used in order to identify and track tags attached to the objects, which will further be stored in the database. The system has been deployed in a local server as well as in Microsoft Azure Cloud. Further the system will be having two types of users, VIP and the regular one.

The system has been designed by segregating the users into two, regular ones for whom the slots would not be reserved and they have to park only on the available ones whereas the VIP ones can have their slots reserved, also they would be having their own RFID tag whereas the others have to take it while entering in the area itself. The system is further being segregated into two, the entry system and the other is the exit system. The entry system would store the data of the users with the scan of the RFID tags (for the regular ones) or the scanned VIP’s cards. While exiting, as per the delayed time from the allotted one the payment of the user would be calculated which can be paid in postpaid and prepaid manner as well. The system also provides the space of two admins as super admin and admin as well and further the access will differ as per the designation as well.

There are multiple hardware's being used in the system, the RFID booth while entrance will be using ATmega328P along with the 32k ROM AND 2k RAM as the microcontroller, the card being scanned would be storing the card number along with the vehicle details. The camera would be capturing the images of the vehicle maintaining the security as well. Also the web server and DB server would be used. The User Interface of the system will be designed with the help of Java and JDBC working for the database with the help of MYSQL. The components required for the approach are readily available and one can use a cloud server in order to have remote access for the system, but the use of a cloud server may affect the efficiency of the system.

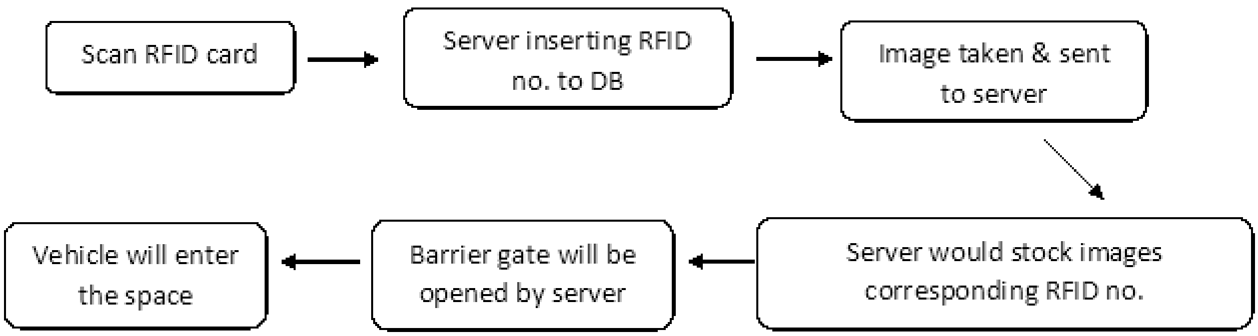


Fig. 1: Workflow diagram for the proposed approach

The system presented in [12] is focused on the idea of Internet of Things with the help of mobile applications connecting with the cloud. The system has aimed towards using cloud computing along with the IoT providing a good and low cost storage capacity and the data stored there can be retrieved with the help of IoT providing the real time processing along with providing communication resources. The proposed system focused upon the integration of Internet of Things with that of Cloud computing in order to get an improved functionality providing a better storage capacity for any kind of data and also it provides the computation needs required by the internet of things. Also this integration focuses on providing a cheaper and effective communication facility along with a better scalability approach.

The architecture of the proposed system has been segregated into several actors as per their uses, the parking sensors like Infrared, Passive in order to identify the vacant parking spaces followed by the processing unit consisting of Raspberry pi working as an intermediate between the cloud and the sensors. The TCP/IP protocol will develop the connections among the remote locations. The mobile applications will act as an interface for the user consisting of the system being designed via different languages and servers along with the data transfer as well. The IBM MQTT server will be hosted on cloud, keeping the track and records of the vehicles being parked and the spaces being vacant stored in the database. All the transmission of data would be handled via the JSON format between the server and the application. The database will track the payment, time duration permitting the system to add any number of users in the database due to its flexibility. With the help of mobile applications and following several steps users can easily get their cars being parked.

IV. Image Processing & Artificial Intelligence based Approach

The proposed system in [9] is highly focused in order to replace the existing systems and has aimed not to use sensors and so is using image processing algorithms in order to automate the parking with the image from security cameras in the parking spaces. The algorithm would try to detect empty parking spaces and communicate information to drivers entering the parking space. The system has been implemented in MATLAB, by following some of the steps like that of image identification, acquisition, conversion thereby followed by enhancement and detection.

The architecture of the system has been segregated into several parts, the first step is of the image identification that is the coloured image would be converted into the HSV image describing the saturation variations of the image. This step would help the user to differ the green circle as per the input RGB value. Further the image might be converted to binary image with a specific threshold, less than which the image might come out as total black or white. The acquisition part will help in order to detect the vacant parking spaces with the help of the cameras. After having the view of the vacant spaces, the image would be converted in order to identify the objects. The architecture would be followed by the enhancement part, that would be done with the help of dilation as well as erosion. Dilation and erosion are a kind of opposites of each other, dilation increasing the boundaries in order to fill up the spaces in the objects followed by the erosion thereby decreasing the boundaries differing the objects and this process would help in distinguishing in a better way, also helping in identifying the vacant spaces. The last step for the algorithm is the detection that would be done with the help of Circle Hough Transform that would be helping extracting the circles. As soon as the circles would be detected the diameter of each circle would be identified. The number of circles will be depicting the number of vacant spots.

The system given by [11] is focused towards image processing and artificial intelligence, consisting of various parts of the detection stage of license plate, information processing control system, network and application. The system uses Open ALPR and Node-RED along with some hypotheses as well, in order to implement the proposed objective. The camera's will be capturing the images of the license plates, thereby identifying if the car is parked or not. The ultrasonic waves will be used in order to identify and confirm the parking scenarios. The image processing step will be implemented in order to complete the first step of detection of the plate numbers with the help of Node-RED for the implementation part and which in turn will be using the tool Open ALPR.

The image processing will be conducted by segregating into several parts starting from the conversion from the coloured images to grayscale in order to identify the objects more clearly to the image acquisition which will be performed with the help of ultrasonic waves thereby confirming if the car has been parked or not, followed by the Node-RED and Open ALPR to be used in order to identify the results. The mobile application will also be segregated into different parts beginning with the time and the fee for the parking to the place for parking manager as well followed by the warnings for the ones not following the rules as well. The system requires quite a number of hardware as well for the implementation like, the communication hub acting as an interface in order to deploy the system and that interface will be Raspberry PI 3 board offering the peripherals with interface. This module will also communicate with that of cloud over the network along with the module of USB adapter to be used in order to transform the Raspberry Pi into a Wi-Fi router as well.

The system discussed in [14] presents a proposal for an identification and recognition system which provides a highly efficient system and can be used with respect to electronic toll collection as well as the check points. In order to maintain a uniqueness, the registration plates will be scanned via different recognition techniques. The presented system starts with capturing the image, followed by detection of the plates thereby segmenting and changing the files from the above step. The third step comes up with the idea of normalization and conversion of images into a binary one in order to create a background separation. Further the next step comes up with the use of OCR recognizing the characters of the plate. And at last the license plate will be detected.

The license plate detection will further be divided into several sub steps beginning with first acquisition of the image along with segmentation the number plate converting into a variety of useful formats segmenting and labelling characters followed by character recognition providing the output file at the last.

a) Miscellaneous Approaches

The approach discussed in [8] focuses on working on Iot and wi-fi technology providing a real time system. This parking system aims to ensure the user a real time reservation before the time of arrival. The proposed system has been worked out using a mobile application connected to Wi-Fi. The system will be using infrared sensors in order to monitor the free parking spaces. The user would need to check for the available spaces with the help of mobile application and further he/she can book the slot that they want to and the information would be shared with the users via notification. The details would be updated in the system as well. The architecture of the proposed system will consist of various elements like infrared sensors, LED lights, microcontrollers etc. The user would be needed to install the application for reserving their slots as per the available spaces. The user can decide the slot and park the car with the help of wi-fi connections via which the links would be created, either by using the IP address. The infra-red sensors would help in detecting objects or any obstacles, when the vehicle comes into space the sensor will transmit the modulated IR light, detecting the vehicle. Further the LEDs would simply be used in order to depict the empty and busy slots. The personal system will be keeping all the records of the whole system. It would be monitoring the count of vehicles being parked or left along with the payment procedures.

The system proposed by Bibi N. in [13] presented a vision based smart parking framework having the method of calibration in order to get the parking area to be segmented into blocks. The system will be dividing the process in different steps, starting with a web camera taking images and further performing image processing in order to represent car presence, counting them and even locating parking slots and further updating the status on the entrance. The video taken via camera would be segmented into frames, further the key frames will be extracted from different angles and the motion of the car will be detected by the key frame subtraction. The steps for thresholding, filtering and further creating frames round the slots would be created. The implementation of the proposed system will be performed via MATLAB and further the efficiency will be calculated as per the slots, number of cars and further taking the predicted numbers of the car. The idea of smart car parking proposed in [10] aims for the single or multi floor parking spaces with the help of a partial automated system. The system also focuses to let the user reach the nearest parking slot via less traffic route. The system works with the help of several different equipment like during the entrance of the car. The IR sensors will be identifying its presence thereby opening the gates only if some vacant spaces are present. Several IR sensors would be installed near the slots updating information to the microcontroller whether there is available space or not. Further the slot would be selected by prioritising the path, slot, as well as the traffic congestion while reaching there. LED would help in detecting the suitable path indicating the user to use that route.

The IR sensors will help in detecting the available spaces, and the LED's will be indicating the path for the specified paths. The system will be working on the objective of combinations, the several combinations of LED paths will be stored in the microcontroller as per the priority of distance and the turns as well. The system will be using a PIC microcontroller providing a platform for all the operations, it acts as the main component controlling the working of all the other components. Apart from LED's and the controller, the DC motor will be used for the gates during the entry or exit. The actions will be converted to the commands with the help of electromagnetic Relays with a good supply.

V. Conclusion & Comparative Study

This paper presents an overview of the different techniques being researched upon by different people in order to develop an efficient algorithm for a smart car parking system. The approaches involved technologies like that of IOT, deep learning, AI etc. The most used approach is IOT and use of RFID tags and sensors. The approaches mentioned above do present efficient ways for the implementation of the algorithm but there are some disadvantages as well. Some of the approaches including sensors or RFID's turns out to be very expensive and are quite problematic to implement as well. There are systems being implemented by IOT having lots of hardware requirements and costing a great expense as well while on the other side there are systems trying to solve the disadvantages of the previous ones.

Ref. no.	Method Used	Advantages	Disadvantages
Denis Ashok et. al[1]	IOT	1) Saves the customer time. 2) Provides a better safety constraint. 3) Provides Real Estate Optimization along with planning.	1) Requires a scope of improvement. 2) Low transmission. 3) Can't be used in an outdoor wi-fi system, due to the limited coverage system. 4) The privacy leakage
Jahnvi Nimble et. al[2]	IOT (LED/RFID)	1) Efficient as due to its automation technique the parking system works quickly and efficiently. 2) Requires low maintenance. 3) The highly sensitive sensors will make the work easier and are easy to handle.	1) High cost when needed to be designed for a larger area. 2) Due to the use of several hardware components it will somehow affect the expenditure of the system.
ElakyaR et. al[3]	IOT (GSM)	1) Users don't really need to wait as they will be notified for occupied as well as vacant spaces. 2) Saves time. 3) Users having access to the parking area.	1) The system consists of several hardware components that would be difficult to maintain. 2) Requires more expenditure.
Wael Alsafery et. al[4]	CLOUD BASED	1) Reducing time. 2) Reduces the energy of the user. 3) Provides an effective approach for the cities with humongous traffic. 4) The system traces the shortest path to the vacant slots.	1) The system is quite expensive. 2) Tedious to maintain.
Praveen, M., & Harini, V.[5]	NB-IOT BASED	1) Provides deeper network coverage and signals penetrating through underground. 2) NB-IoT provides a stable span of four to five years.	1) Quite expensive. 2) Requires more hardware. 3) Requires a lot of time in maintaining the system. 4) The devices on the network must be paid and the addition of telecommunication taxes increases the expenditure as well.

Global Journal of Researches in Engineering (F) Volume XXII Issue II Version I Year 2022

Bonde, et. al[6]	IOT (GSM)	1) Provides a successful allotment of free parking slots to cars. 2) Tracing the proper path towards the slot. 3) LCD displaying allotment and de-allotment properly.	1) It requires a lot of time to install. 2) The system turns out to be quite expensive.
Chowdhury et. al[7]	CLOUD-OF-THINGS	1) It provides all in one facility along with the payment options. 2) Provides reserved spaces for VIP's. 3) Highly Secure.	1) Requires a lot of hardware. 2) High Expenditure. 3) Requires a lot of time in installation.
Jayakshei Dadaji Bachhav et. al[8]	WI-FI TECHNOLOGY	1) The system facilitates a user-friendly environment. 2) Less time for the user in finding the slots. 3) Provides more security to the user.	1) Consumes a lot of power. 2) If the sensor gets affected due to weather it will need to be replaced too.
Soundarya Rajesh et. al[9]	IMAGE PROCESSING	1) The system ensures reduced mechanical and electrical liability as there is no use of sensors. 2) High level of security as the cameras would be installed for the image capture.	1) The system requires a power source ensuring the cameras and lighting for camera imaging. 2) Weather conditions might affect the visibility.
Balwant K. Patil et. al[10]	SENSOR BASED	1) Reduces User's time. 2) Helps in traffic management. 3) Provides a mode of communication with the drivers for the parking.	1) The system facilitates higher performance in order to track the car but is not fully an automated system. 2) Requires a high level of maintenance.
Jiang Ruili et. al[11]	IMAGE PROCESSING & ARTIFICIAL INTELLIGENCE	1) Provide a long term area for expansion as well as solutions for problems. 2) The ANPR efficient cameras provide a good level of precision. 3) The system integrates several technologies providing every details of the vehicles to the system securely.	1) Requires a high power supply 2) High battery backup required. 3) The sensitivity elements of ultrasonic can get mechanically damaged and the risk of change in the range of ultrasonic sensors due to the weather comes out as another problem in this space.
Abhirup Khanna et. al[12]	CLOUD-OF-THINGS	1) Provides good and low cost storage capacity. 2) The system ensures the backup of the data in the cloud in order to have recovery in case of any damage to the system.	1) This system is quite complex in design. 2) Not provide much of aflexible way to park.
Bibi, N., Majid et. al[13]	MATLAB	1) Cost effective. 2) Optimize the identification of available parking slots to reduce congestion in the parking area.	1) Time Consuming 2) Includes a number of steps which makes it a bit complex.
Jaspreet Kaur et. al [14]	IMAGE PROCESSING & ARTIFICIAL INTELLIGENCE	1) Acts a multi purpose parking system helping in various activities.	1) With time the maintenance of hardware will also be required. 2) Cost of the system is more.
Vinay Raj Tripathti [15]	IOT	1) Saves fuel consumption. 2) Saves the user's time. 3) Helps in reducing traffic congestion. 4) Controls pollution.	1) A lot of hardware will be required which will lead to more cost and will also need more maintenance.

Global Journal of Researches in Engineering (F) Volume XXII Issue II Version I Year 2022

References Références Referencias

1. Prof. Denis Ashok (Ph.D), Akshat Tiwari, Vipul Jirge (2020), Smart Parking System using IoT Technology, 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE).
2. Jahnvi Nimble, Priyanka Bhegade, Snehal Surve, Priya Chaugule, (2016) Automatic Smart Car Parking System, International Journal Of Advances in Electronics and Computer Science, Vol-3, Mar-2016.
3. ElakyaR, Juhi Seth, Pola Ashritha, R Namith (2019), Smart Parking System using IoT, International Journal of Engineering and Advanced Technology (IJEAT), Vol-9, Octorber 2019.
4. Wael Alsafery, Badraddin Alturki, Stephan Reiff-Marganiec & Kamal Jambi. Smart Car Parking System Solution for the Internet of Things in Smart Cities.
5. Praveen, M., & Harini, V. (2019). NB-IOT based smart car parking system. 2019 International Conference on Smart Structures and Systems (ICSSS).
6. Bonde, D. J., Shende, R. S., Kedari, A. S., Gaikwad, K. S., & Bhokre, A. U. (2014). Automated car parking system commanded by Android application. 2014 International Conference on Computer Communication and Informatics.
7. Chowdhury, L. H., Mahmud, Z. N.. Z., Islam, I.-U., Jahan, I., & Islam, S. (2019). Smart Car Parking Management System. 2019 IEEE International Conference on Robotics, Automation, Artificial-Intelligence and Internet-of-Things (RAAICON).
8. Jayakshei Dadaji Bachhav1; Dept. Of Electronics and Telecommunication, SNJB's COE, Chandwad, Maharashtra, India, Prof. Mechkul M. A.2; SDept. Of Electronics and Telecommunication, SNJB's COE, Chandwad, Maharashtra, India," Smart Car Parking System", (IRJET), Volume: 04 Issue: 06 | June-2017.
9. Soundarya Rajesh, Dr. M. G. Sumithra, "Smart Parking system using Image processing", International Research Journal of Engineering and Technology (IRJET), Vol 05, Issue 04, Apr42018.
10. Balwant K. Patil, Avinash Deshpande, Sonal Suryavanshi, Rudresh Magdum, Manjunath, "Smart Parking System for Cars", International Conference on Recent Innovations in Electrical, Electronics & Communication Engineering (ICRIEECE).
11. Jiang Ruili, Wang Haocong, Wang Han University of Electronic Science and Technology of China, Chengdu, China; Dr Eoin O'Connell Computer Science and Information Systems Department University Of Limerick; Dr Sean McGrath Electronic & Computer Engineering Department University Of Limerick, "Smart Parking System Using Image Processing and Artificial Intelligence", International Conference on Sensing Technology (ICST)-2018.
12. Abhirup Khanna; Rishi Anand, University of Petroleum and Energy Studies (UPES) Dehradun, Uttarakhand, "IoT based Smart Parking System"; 2016 International Conference on Internet of Things and Applications (IOTA) Maharashtra Institute of Technology, Pune, India 22 Jan - 24 Jan, 2016.
13. Bibi, N., Majid, M. N., Dawood, H., & Guo, P. (2017). Automatic Parking Space Detection System. 2017 2nd International Conference on Multimedia and Image Processing (ICMIP).
14. Jaspreet Kaur, (2019). Implementation of Smart Parking using Artificial Intelligence; Computer Science and Engineering, Patiala Institute of Engineering and Technology for women, Nandpur kesho. August 2019 IJSDR, Volume 4.
15. Vinay Raj Tripathti, Dept. of Electrical & Electronics, KIET Group of Institutions, Ghaziabad; 2020 International Conference on Electrical and Electronics Engineering (ICE3-2020).

Global Journal of Researches in Engineering: F
Electrical and Electronics Engineering
Volume 22 Issue 2 Version 1.0 Year 2022
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

AFIS based Advanced Power Control Scheme for Grid-Connected DFIG-Driven WECS

By Ifte Khairul Amin & M. Nasir Uddin
Shahjalal University of Science & Technology

Summary- In wind energy conversion system, extraction of optimum power and efficient operation are two major challenges. In grid connected mode, a doubly fed induction generator (DFIG) control unit is designed to operate at optimum speed to deliver maximum output power in the grid while the voltage, frequency and harmonic regulations need to be fulfilled. Vector control associated with proportional-integral (PI) controllers has been widely applied in wind farms for reliable power regulation of DFIG. As DFIG based wind energy conversion system (WECS) experiences strong nonlinearity and uncertainties originated from the aerodynamics of the wind turbine and magnetic saturation of the generator, different adaptive and nonlinear control schemes have been proposed to resolve the problems associated with fixed-gain PI controllers.

Keywords: on-line tuning, AFIS control, doubly fed induction generator, wind energy conversion system, power control.

GJRE-F Classification: DDC Code: 621.312136 LCC Code: TJ820

AFISBASEDADVANCEDPOWERCONTROLSCHEMEFORGRIDCONNECTEDDFIGDRIVENWECS

AFIS based Advanced Power Control Scheme for Grid-Connected DFIG-Driven WECS

Ifte Khairul Amin [α] & M. Nasir Uddin [σ]

Summary- In wind energy conversion system, extraction of optimum power and efficient operation are two major challenges. In grid connected mode, a doubly fed induction generator (DFIG) control unit is designed to operate at optimum speed to deliver maximum output power in the grid while the voltage, frequency and harmonic regulations need to be fulfilled. Vector control associated with proportional-integral (PI) controllers has been widely applied in wind farms for reliable power regulation of DFIG. As DFIG based wind energy conversion system (WECS) experiences strong nonlinearity and uncertainties originated from the aerodynamics of the wind turbine and magnetic saturation of the generator, different adaptive and nonlinear control schemes have been proposed to resolve the problems associated with fixed-gain PI controllers. Among adaptive controllers, adaptive fuzzy inference system (AFIS) has the distinguishing feature of modeling a highly nonlinear system and adopting the uncertainties. Hence; in this paper, an AFIS based NFC controller is proposed to regulate the converters of grid-connected DFIG. The proposed algorithm is tested for variable wind speed conditions and the results are compared with fixed gain PI controller and adaptive back-stepping based nonlinear controller. The simulation results suggest that the proposed scheme shows excellent adaptation with the variable condition through the change of its parameters and comparatively better performance in terms of speed and current tracking.

Keywords: on-line tuning, AFIS control, doubly fed induction generator, wind energy conversion system, power control.

List of Symbols and Abbreviations:

$v_{ds}, v_{qs}, v_{dr}, v_{qr}, v_{dc}, v_{qc}$ —d-q axis stator, rotor, grid converter voltages (V)

$i_{ds}, i_{qs}, i_{dr}, i_{qr}, i_{dc}, i_{qc}$ — d-q axis stator, rotor, grid converter currents (A)

R_s, R_r— Stator, rotor and core loss resistances (Ω)

ω_s, ω_r—synchronous and rotor electrical angular speed (rad/s)

P—Number of pole pairs

$L_s = L_{\sigma s} + L_m$ —Stator self-inductance (H)

$L_r = L_{\sigma r} + L_m$ —Rotor self-inductance (H)

$L_{\sigma s}, L_{\sigma r}$— Stator and rotor leakage inductances (H)

L_m— Magnetizing inductance (H)

T_e-Electromagnetic developed torque (N-m)

Q_s, Q_{grid} – Reactive power in the stator side and grid

T_t- Turbine torque (N-m)

V_{bus} – Bus voltage

V_{grid} -Grid voltage

Author α: Associate Professor, Department of EEE, Shahjalal University of Science & Technology, Sylhet, Bangladesh.
e-mail: iamin@lakeheadu.ca
Author σ: Department of Electrical Engineering, Lakehead University, Barrie, Ontario, Canada.

I. Introduction

Among the major challenges of WECS, controlled extraction of power from intermittent generation and supervision on nonlinear system dynamics of DFIG-WECS are of critical importance. Different optimum point search algorithms have been proposed in [1-5] to find out the peak power generated by the WECS. The conventional vector control scheme involves cascaded control loops where simple proportional-integral (PI) controllers are executed to regulate the voltage/current [6-8]. The fixed gain PI controllers may fail to implement proper tracking performance if the constants are not selected appropriately. Furthermore, the performance of the PI controller deteriorates with the variation in machine parameters due to the change in temperature, magnetic saturation and machine-aging. Since DFIG inherits nonlinear magnetization characteristics, nonlinear control techniques are adopted to achieve enhanced dynamic behavior for the control operation of the system. Hence, the researchers have focused on more sophisticated problems for WECS control, such as backstepping based nonlinear control [9], fuzzy logic control [10], sliding mode control [11] etc. The major drawback of the reported fuzzy inference system is that it is completely based on the knowledge and experience of the designer [12]. Intelligent control algorithms such as neural network (NN)[13], neuro-fuzzy control (NFC)[14], adaptive network-based fuzzy inference system (ANFIS)[15], genetic algorithm[16], particle swarm optimization[17], artificial bee colony algorithm[18], grey wolf optimization[19] have been gaining popularity over the last decade. Among the intelligent control algorithm, AFIS combines the competence of fuzzy reasoning in handling uncertainties and learning aptitude of adaptive network from complex system. Also, the algorithm is capable to model the nonlinear features of a system. Therefore, an AFIS based NFC controller is designed for converter control for real and reactive power control of grid-connected DFIG based WECS to extract maximum power from the wind. The performance of the AFIS controller has been investigated with the fixed gain PI and adaptive backstepping based nonlinear controllers under various operating conditions. The simulation

Global Journal of Researches in Engineering (F) Volume XXII Issue II Version I Year 2022

results demonstrate the efficacy of the AFIS algorithm over other controllers for its intelligent pattern recognition scheme.

II. Proposed Configuration of the System

In the proposed configuration, the DFIG is mechanically coupled with the turbine to transform the mechanical energy into electrical energy. A back-to-back converter is implanted to perform independent control of DC-link voltage and decoupled control of real and reactive power. Separate control circuits are required to regulate the grid-side converter (GSC) and rotor side converter (RSC) as shown in Fig. 1. Adaptive fuzzy scheme with on-line tuning feature is implemented to design the proposed controllers. The turbine, DFIG and grid parameters are shown in Table 1.

a) AFIS Structure

AFIS can be considered as an intelligent and powerful processing tool for pattern recognition and controller design because it combines the advantages of both the fuzzy logic and online parameter adaptation. The following subsections illustrate the structure of AFIS network and demonstrate the AFIS based controller configuration of the DFIG-WECS primarily linked with grid.

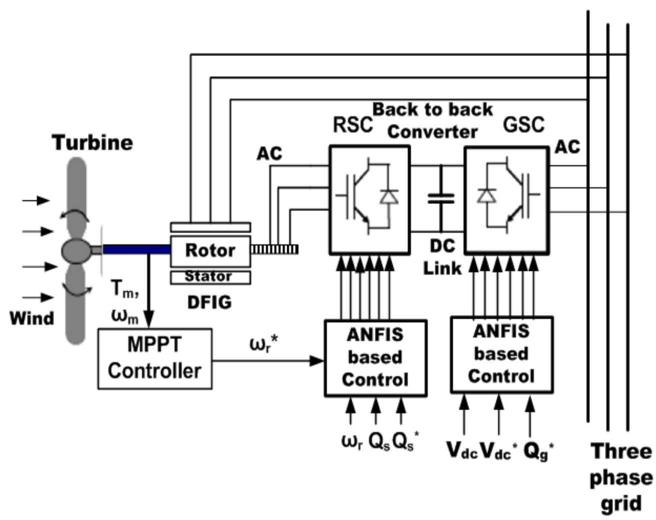


Fig. 1: Full configuration of the proposed AFIS controller based DFIG-WECS

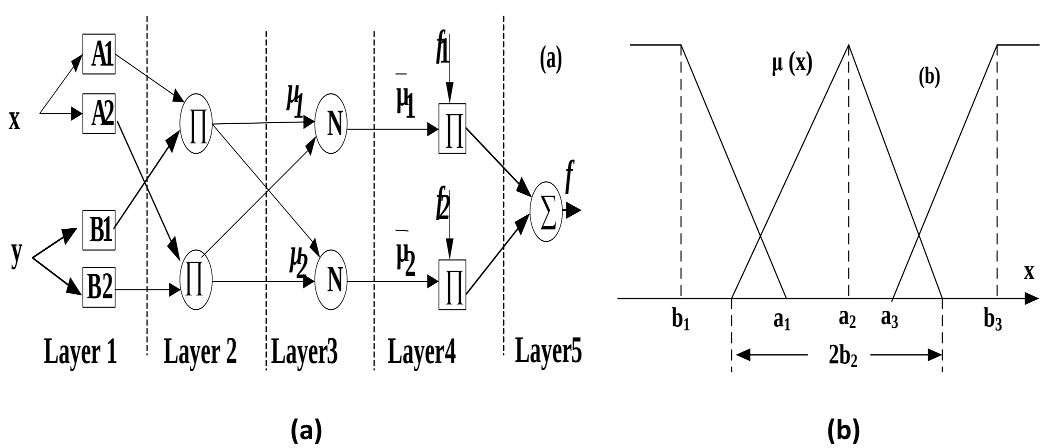


Fig. 2: (a) Schematic of AFIS architecture (b) Membership function for input data x

i. *AFIS Layers*

Adaptive fuzzy inference system consists of a fuzzy inference system whose membership functions can be reconstructed by using an authentic input-output data set. The parameters associated with the membership functions are obtained by gradient descent algorithm. When the gradient vector is determined, it utilizes least square error calculation method to adjust the parameters to reduce the error function. AFIS networks usually utilize a combination of least squares estimation and back propagation for membership function parameter estimation. The details of AFIS structure can be found in [20, 21].

The controller for the converters is designed by utilizing fuzzy logic and adaptive neural network algorithms. AFIS can be considered as an intelligent and powerful processing tool for pattern recognition and controller design because it combines the advantages of both the fuzzy logic and neural network algorithms. The parameters associated with the membership functions are updated by gradient descent algorithm. When the gradient vector is determined, it utilizes one of its optimization techniques to adjust the parameters to reduce the error function. AFIS networks usually utilize a combination of least squares estimation and back propagation for membership function parameter estimation. Fig. 2(a) and 2(b) illustrates a generalized configuration and membership function for the proposed AFIS network, respectively. The description of each layer in the AFIS structure is explained in the following section.

Layer 1: The first layer is also known as the fuzzification layer, a number of membership functions are assigned to each input. Only one input is used in this layer which is the normalized error function of bus voltage (V_{bus}), rotor speed (ω_r), reactive power (Q_s) based on the converter control.

$$x = \frac{\alpha - \alpha_{ref}}{\alpha_{rated}} \tag{1}$$

Here, $\alpha = \omega_r, V_{bus}$ or Q_s.

The membership functions are defined in this stage. The equations for the membership function are defined in (2-4).

$$\mu_{A1}^{1}(x) = \begin{cases} 1, & x \le b_1 \\ \frac{x-a_1}{b_1-a_1}, & b_1 < x < a_1 \\ 0, & x \ge a_1 \end{cases} \tag{2}$$

$$\mu_{A2}^{2}(x) = \begin{cases} 0, & |x| \ge b_2 \\ 1 - \frac{x-a_2}{b_2}, & |x| < b_2 \end{cases} \tag{3}$$

$$\mu_{A3}^{3}(x) = \begin{cases} 0, & x \le a_3 \\ \frac{x-a_3}{b_3-a_3}, & a_3 < x < b_3 \\ 1, & x \ge b_3 \end{cases} \tag{4}$$

where, x is the input for the membership function calculation block, a_1, b_1, a_2, b_2, a_3 and b_3 are the parameters defined in the corresponding membership function which needs to be tuned during control action. The parameter a_2 is selected as zero to reduce the computational burden.

Layer 2: In this layer, each node multiplies the entering signals and directs the output to the next level that represents the individual firing strength μ_i of a rule.

$$\mu_i = \mu_{A1}^{i}(x)\mu_{A2}^{i}(x)\mu_{A3}^{i}(x) \tag{5}$$

For the proposed controller only one input is chosen. So, the second layer can be ignored and the output of first layer goes to the third layer.

$$\mu_1 = \mu_{A1}^{1}(x), \mu_2 = \mu_{A2}^{2}(x), \mu_3 = \mu_{A3}^{3}(x) \tag{6}$$

Layer 3: Each block in the third layer which is also known as normalization stage, estimates the proportion of the i-th rule firing strength ($\bar{\mu}_i$) to the sum of the firing strength of all rules.

$$\bar{\mu}_i = \frac{\mu_i}{\mu_1+\mu_2+\mu_3} \tag{7}$$

Layer 4: In this layer, the function, fi is calculated as the linear activation function. A single input first order Sugeno fuzzy model is utilized in this model.

$$f_1 = \beta_0^1 + \beta_1^1 x \tag{8}$$

$$f_2 = \beta_0^2 + \beta_1^2 x \tag{9}$$

$$f_3 = \beta_0^3 + \beta_1^3 x \tag{10}$$

In this stage, the parameters β_o, β_1 are tuned based on the operating condition of DFIG. These parameters are known as consequent parameters.

Layer 5: The final layer is the output layer which computes the overall output by combining the incoming data.

$$f = \bar{\mu}_1 f_1 + \bar{\mu}_2 f_2 + \bar{\mu}_3 f_3 \tag{11}$$

ii. *Online self-tuning algorithm*

It is impossible to calculate the desired outputs of the AFIS controller for all possible conditions, which are d-q axis currents for rotor and grid side control (i_{dr}, i_{qr}, i_{dg}, i_{qg}). Hence training data sequence can't be obtained especially for variable wind speed. Therefore, an unsupervised self-tuning algorithm is developed in the paper. The controller targets to minimize the objective function which is a squared normalized error function of the AFIS controller input. The objective function is defined as,

$$W = \frac{1}{2}e^2 = \frac{1}{2}\left(\frac{x^*-x}{x_{rated}}\right)^2 \tag{12}$$

where x^*, x and x_{rated} are the reference, actual and desired value of the variable and x is scalar.

iii. *Tuning of Pre-Condition and Consequent Parameters*

The learning rule of the proposed controller can be given as [22]:

$$a_i(n+1) = a_i(n) - \gamma_{ai}\frac{\partial W}{\partial a_i}, b_i(n+1) = b_i(n) - \gamma_{bi}\frac{\partial W}{\partial b_i} \tag{13}$$

Where, γ_{ai} and γ_{bi} are the learning rates of the corresponding parameters. The derivatives can be defined as:

$$\frac{\partial W}{\partial a_i} = \frac{\partial W}{\partial e}\frac{\partial e}{\partial x}\frac{\partial x}{\partial f}\frac{\partial f}{\partial \mu_{Ai}^{i}}\frac{\partial \mu_{Ai}^{i}}{\partial a_i} \quad , \quad \frac{\partial W}{\partial b_i} = \frac{\partial W}{\partial e}\frac{\partial e}{\partial x}\frac{\partial x}{\partial f}\frac{\partial f}{\partial \mu_{Ai}^{i}}\frac{\partial \mu_{Ai}^{i}}{\partial b_i} \tag{14}$$

Now we get, $\frac{\partial W}{\partial e} = e = \frac{x^{*}-x}{x_{rated}}, \frac{\partial e}{\partial x} = -\frac{1}{x_{rated}}$ and $\frac{\partial x}{\partial f} = J$, assuming J is the Jacobian matrix of the system. It is very difficult to determine system's Jacobian matrix. For decoupled control of DFIG, the system is assumed as a single input single output system and then the Jacobian matrix is considered as a positive constant. Considering that the effect of J is included in tuning rate parameter, the update rule for the consequent parameter is given as:

$$a_1(n+1) = a_1(n) - \gamma_{a1} e(n) \frac{f_1(n)}{\sum \mu_{A1}^{1}} \frac{1-\mu_{A1}^{1}(n)}{b_1(n)-a_1(n)} \tag{15}$$

$$b_1(n+1) = b_1(n) - \gamma_{b1} e(n) \frac{f_1(n)}{\sum \mu_{A1}^{1}} \frac{\mu_{A1}^{1}(n)}{b_1(n)-a_1(n)} \tag{16}$$

$$b_2(n+1) = b_2(n) + \gamma_{b2} e(n) \frac{f_2(n)}{\sum \mu_{A2}^{2}} \frac{1-\mu_{A2}^{2}(n)}{b_2(n)} \tag{17}$$

$$a_3(n+1) = a_3(n) - \gamma_{a3} e(n) \frac{f_3(n)}{\sum \mu_{A3}^{3}} \frac{1-\mu_{A3}^{3}(n)}{b_3(n)-a_3(n)} \tag{18}$$

$$b_3(n+1) = b_3(n) - \gamma_{b3} e(n) \frac{f_3(n)}{\sum \mu_{A3}^{3}} \frac{\mu_{A3}^{3}(n)}{b_3(n)-a_3(n)} \tag{19}$$

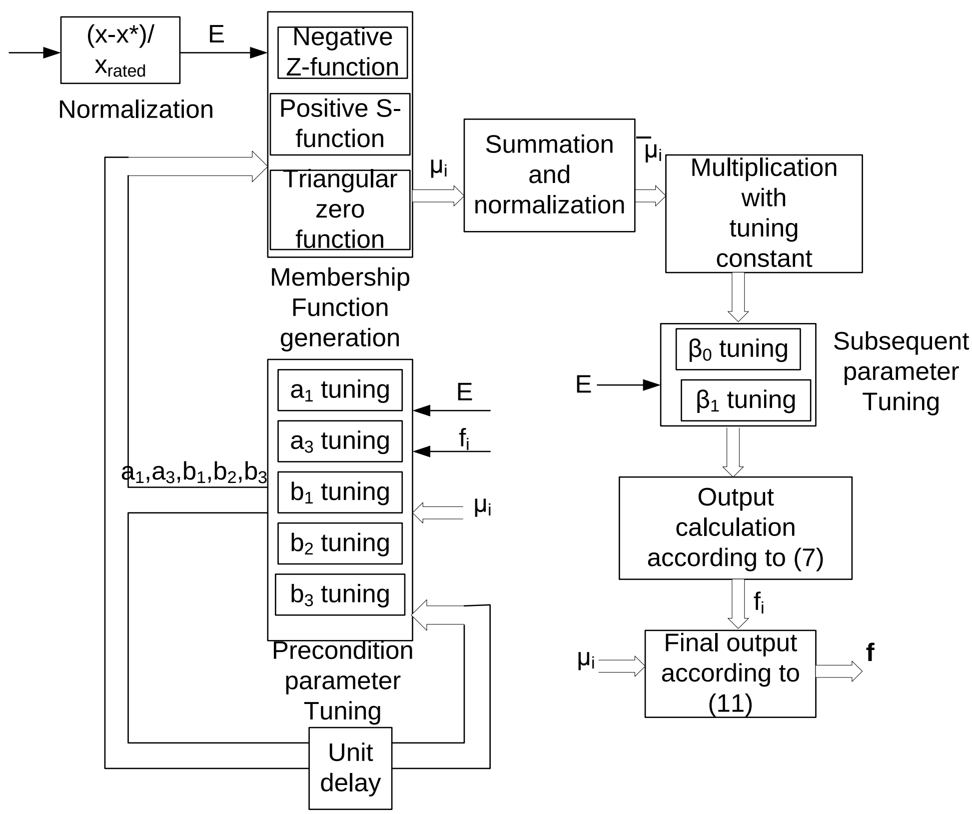


Fig. 3: Output calculation by implementing AFIS algorithm

Similarly, the update laws for tuning the consequent parameters can be derived as follows.

$$\beta_0^i(n+1) = \beta_0^i(n) - \gamma_{\beta_0^i} \frac{\partial W}{\partial \beta_0^i} \tag{20}$$

$$\beta_1^i(n+1) = \beta_1^i(n) - \gamma_{\beta_1^i} \frac{\partial W}{\partial \beta_1^i} \tag{21}$$

$\gamma_{\beta_0^i}$ and $\gamma_{\beta_1^i}$ are the learning rates for the consequent parameters. As discussed in the update laws of precondition parameters, the derivatives can be found from the chain rules.

$$\beta_0^i(n+1) = \beta_0^i(n) - \gamma_{\beta_0^i} e(n) \frac{f_i(n)}{\sum \mu_{Ai}^{i}} \frac{\mu_i}{\mu_1+\mu_2+\mu_3} \tag{22}$$

$$\beta_1^i(n+1) = \beta_1^i(n) - \gamma_{\beta_1^i} e(n) \frac{f_i(n)}{\sum \mu_{Ai}^{i}} \frac{\mu_i x}{\mu_1+\mu_2+\mu_3} \tag{23}$$

Finally, the output (f) will be calculated according to (7)-(11). Fig. 3 shows the parameter update mechanism for the proposed AFIS based configuration.

III. RSC Control

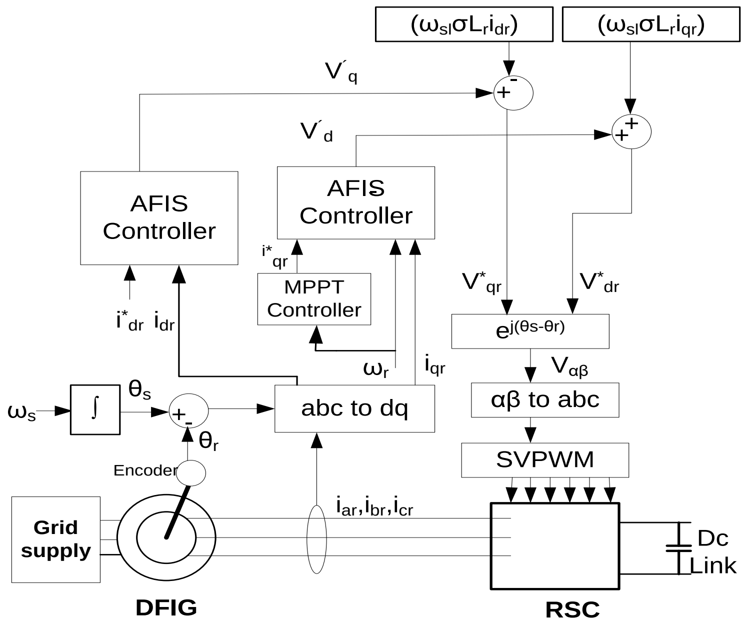


Fig. 4: AFIS architecture based RSC control for grid-connected mode of DFIG

The rotor side converter magnetizes the machine through the rotor side converter. Fig. 4 shows the RSC control scheme using the proposed AFIS architecture for grid connected DFIG. As DFIG provides decoupled control of real and reactive power, two different AFIS structures have been employed to generate the reference d-axis and q-axis rotor voltages (v_{dr}^{*} *and* v_{qr}^{*}).

IV. GSC Control by AFIS Controller

The grid side converter maintains the dc-link voltage constant irrespective of the value and direction of the rotor power flow. The AFIS controller-based configuration is implemented in GSC control to regulate the dc-link voltage as depicted in Fig. 5. The reference q-axis grid current component can be obtained from the reactive power according to (24).

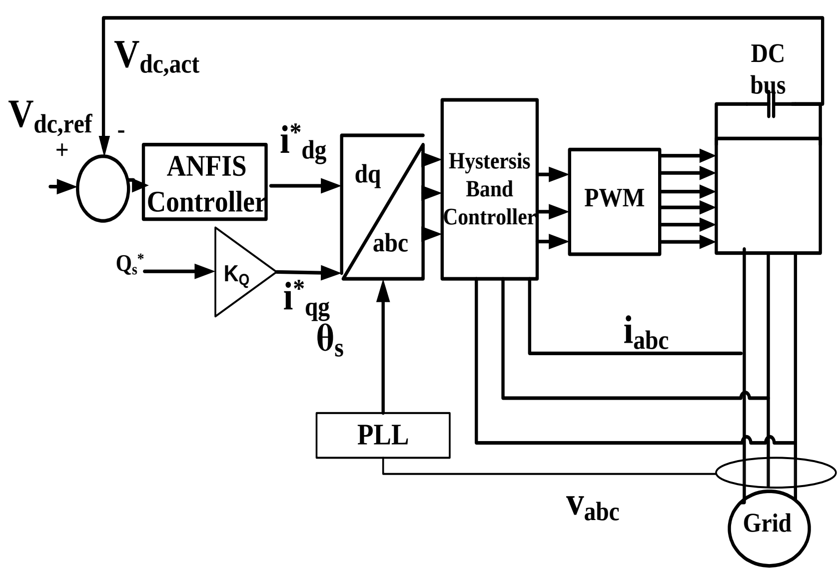


Fig. 5: AFIS based GSC control for DFIG-WECS

$$i_{qg}^{*} = K_Q Q_s^{*} = \frac{Q_s^{*}}{-3/2V_{grid}} \quad (24)$$

The objective function of the AFIS controller will ensure that the bus voltage error is converged to zero.

V. Performance Analysis of the Proposed Scheme

Speed and direction of wind at a location vary randomly with time. Therefore, the adaptability of controller is critical for wind power generators to operate effectively. AFIS based controllers have the unique property of handling uncertainty and fast convergence in varying condition. In this paper, the efficacy of the AFIS controlled RSC for grid connected DFIG is observed under variable wind speed as shown in Fig. 6.

The wind speed variation is depicted in Fig. 6(a). It is found that the AFIS controlled RSC tracks the rotor speed of the generator as dictated by the MPPT control algorithm (Fig. 6(b)). It also regulates the d-q axis rotor currents according to the demanded value to control the real and reactive power of the generator (Fig. 6(c,d)). Similarly, the GSC is controlled by the AFIS based controller which regulates the d-q axis grid current components. The bus voltage regulation performance is depicted in Fig. 6(e). It is found that the AFIS controller is capable to maintain the dc-link voltage to the reference set point which is 1150 V. A hysteresis current controller generates the control pulses for the grid converter. The current d-q axis grid current components and the three phase currents are shown in Fig. 6 (f,g,h).

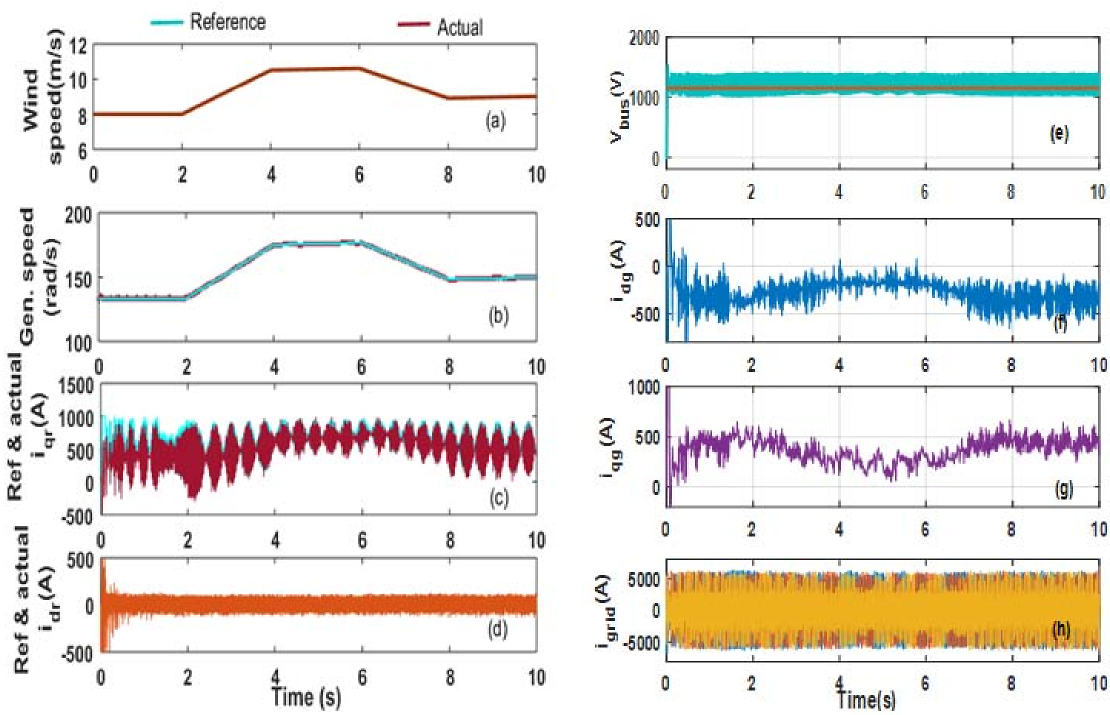


Fig. 6: Performance of the AFIS based RSC and GSC control: (a) Variation in wind speed, (b) Corresponding change in generator speed, (c) Reference and actual q-axis rotor current, (d) Reference and actual d-axis rotor current, (e) Reference and actual DC-link voltage, (f) d-axis grid current component, (g) q-axis grid current component, (h) Three phase grid currents.

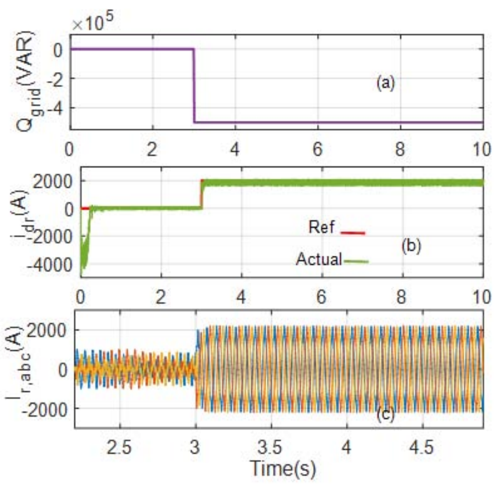


Fig. 7: AFIS based controller performance for step change in reactive power: (a) Variation in reference value of reactive power, (b) Corresponding change inreference and actual d-axis rotor currents, (c) Three phase rotor currents.

In DFIG, it is possible to control the reactive power requirement from RSC. Fig. 7 shows the feature for the proposed controller. The reference reactive power is varied from 0 to -0.5 MVAR by employing step function (Fig. 7(a)). The desired value of d-axis rotor current follows the variation of the reactive power and the actual current component successfully can follow the trajectory of the reference current as observed in Fig. 7(b) and the three phase rotor currents also change accordingly (Fig. 7(c)). The reactive power regulation proves the accuracy and effectiveness of the AFIS structure-based controller in grid-connected DFIG based WECS.

The performance of the grid connected DFIG-WESC has been investigated for conventional PI, nonlinear and AFIS based controllers under various operating conditions. First, the simulation is performed for a step change in wind speed from 6m/s to 8 m/s for each controller. The results are shown in Fig. 8. It is observed from this figure that the PI controller has the largest overshoot and steady-state ripple compared to the other two controllers. In the PI controllers, the proportional and integral constants are selected according to Table 2. The values are calculated according to the DFIG, grid and turbine parameters [6]. The AFIS controller shows excellent speed tracking in terms of steady state error although the settling time is a bit higher than the nonlinear controller. The nonlinear controller for the comparative analysis is derived from the machine motion equation to stabilize the rotor actual speed at the reference rotor speed. The subsystem equations are exploited, and new controllers are derived by defining appropriate Lyapunov function progressively. The process terminates when the control equations for the reference voltages are derived. Backstepping based control approach is adopted to obtain the control laws for the rotor side converter control. The detailed model and equations for the proposed adaptive Lyapunov stability criterion based nonlinear controller can be found in [23,24].

Table 2: PI controller constants for comparative analysis

Rotor side PI controller parameters	Stator side PI controller parameters
$k_{p,idr} = k_{p,iqr} = 2\omega_{idr}\sigma L_r - R_r$ $k_{i,idr} = k_{i,iqr} = \omega_{idr}{}^2\sigma L_r$ $k_{p,\omega r} = 2\omega_b J/P$ $k_{i,\omega r} = \omega_b{}^2 J/P$ $\omega_{idr} = 100 \times \frac{1}{t_{ca}},$ $t_{ca} = \frac{\sigma L_r}{R_r}$ $\omega_b = \frac{1}{t_{cb}}, t_{cb} = 0.005$	$k_{p,vbus} = -10^4$ $k_{i,vbus} = -3 \times 10^5$ $k_{p,icd} = k_{p,icq} = 2\omega_{ic} L_g - R_g$ $k_{i,icd} = k_{i,icq} = \omega_{ic}{}^2 L_g$ $\omega_{ic} = 2\pi f_s$

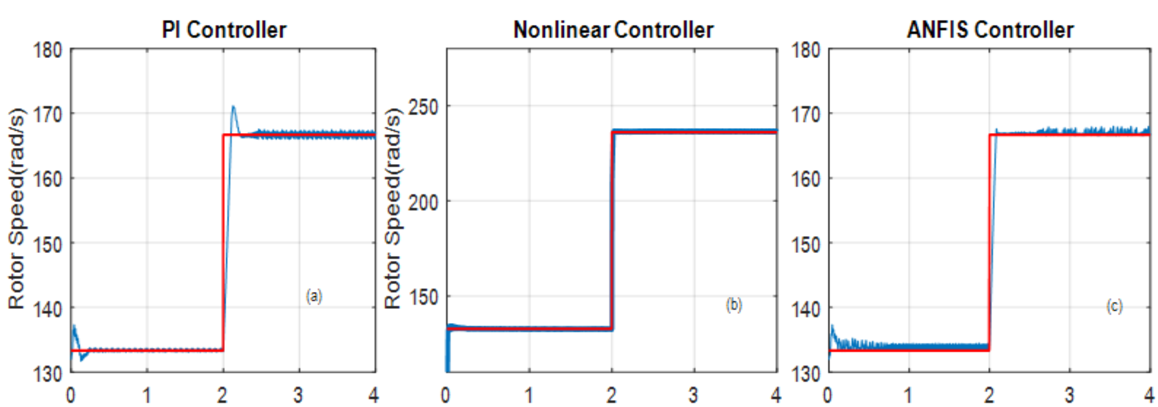


Fig. 8: Comparative rotor speed response for a step increase in wind speed: (a) PI, (b) Nonlinear, (c) AFIS

The dc-link voltage tracking performance of the controllers is also compared and shown in Figs. 9 (a)-(c). The adaptive backstepping based nonlinear controller has very high ripples in dc-link voltage while the AFIS based controller shows the most satisfactory performance in voltage tracking.

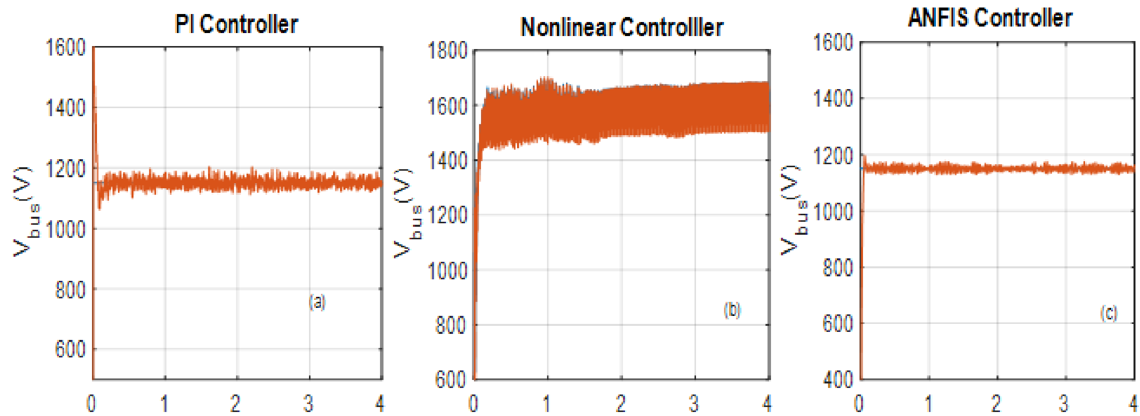


Fig. 9: Comparative dc-link voltage tracking performance at variable wind speed: (a)PI, (b) Nonlinear, (c) AFIS

Similarly, d-axis rotor current responses are investigated in Fig. 10 for a step change in reactive power demand. The PI controller shows fast current tracking while the nonlinear controller displays current tracking with large steady state error. The proposed AFIS controller performer in between these two configurations.

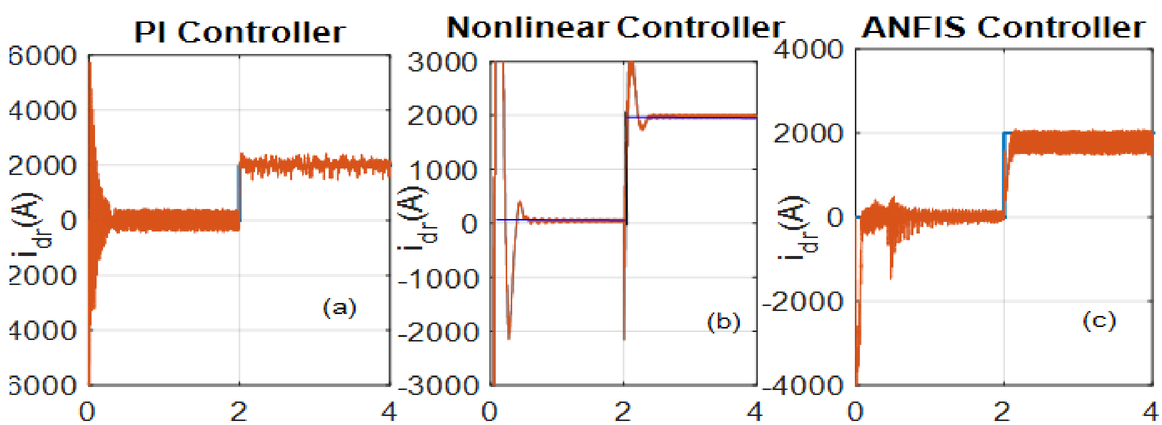


Fig. 10: Comparative d-axis rotor current tracking response for a step change in reactive power demand at t=2 sec: (a) PI, (b) Nonlinear, (c) AFIS

Table 3 shows the detailed comparison among controllers. The proposed AFIS controller shows comparatively better performance in terms of rotor speed convergence, dc bus voltage regulation and grid disturbance minimization whereas the computation burden is high and d-axis current tracking performance is moderate compared to fixed gain PI and adaptive backstepping based nonlinear controllers.

Table 3: Performance comparison among the proposed controllers

Operating condition	Property	PI controller	ABN controller	AFIS based controller
Speed convergence characteristics	Speed settling time	Less than 0.2s	Less than 0.05s	Less than 0.15s
	Speed overshoot	3.5%	0.4%	0.6%
DC bus voltage convergence at variable wind flow	Voltage settling time	Less than 0.1s	Less than 0.05s	Less than 0.05s
	Voltage fluctuation	Low	High	Very low

d-axis rotor current at step rise in reactive power demand	Current settling time	Less than 0.1s	More than 0.5 s	Less than 0.2s
	Steady state error	Negligible	Negligible with very high overshoot	Marginal error with fluctuation
Computational burden	Block computation speed	Low	Medium	High
Ripple in grid currents at fixed wind speed		Lower than other controllers	Very high	High
Performance under Grid voltage disturbance		Good	Moderate	Better than others

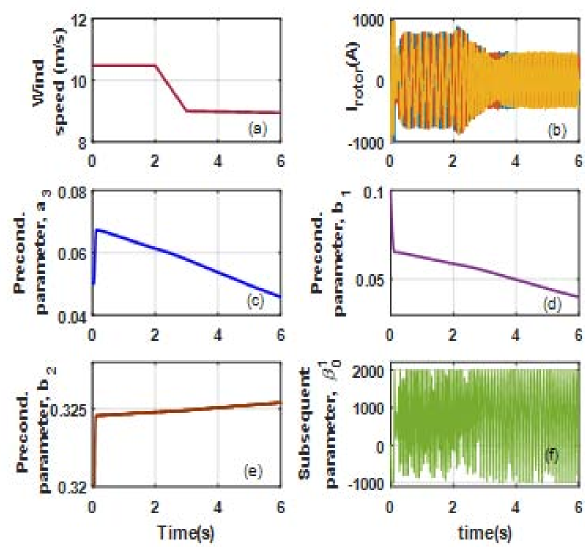


Fig. 11: Parameter updating pattern of online-tuned ANFIS scheme for variation in wind speed: (a) Changes in wind speed, (b) Frequency variation in rotor current, Variation in (c) precondition parameter,a_3 (d) precondition parameter,b_1 (e)precondition parameter,b_2, (f) subsequent parameter,β_0^1

Figure 11 depicts the tuned parameters of the proposed algorithm along with the variation of the wind speed (Fig. 11(a). The amplitude and frequency of the rotor current are shown in Fig. 11(b). Four parameters in the AFIS model are demonstrated in Fig. 11 ((c)-(f)). The variation of three preconditioned parameters, a_3, b_1 and b_2 and one subsequent parameter is β_0^1 is depicted. Hence, the adaptation of parameter in the proposed adaptive fuzzy inference system is proved from the figures.

VI. Conclusion

Simplistic membership function based adaptive fuzzy scheme for DFIG operated WECS has been presented in this paper. The performance of the proposed controller has been investigated for grid-connected machine under different dynamic operating conditions. The simulation results suggest that the RSC controller regulates the power by adjusting the rotor speed and machine torque with the variation of wind speed. Also, the GSC controller is capable to maintain constant dc-link voltage and grid-current components even after abrupt variation of the required power demand and wind speed. Comparative analyses have been performed among the proposed AFIS scheme, conventional fixed-gain PI controller and adaptive backstepping based nonlinear controller. The comparison outcomes suggest the superiority and robustness of the AFIS architecture-based controller in power regulation of DFIG based WECS.

Conflict of Interest Statement

Authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References Références Referencias

1. Wang Q & Chang L, An intelligent maximum power extraction algorithm for inverter-based variable speed wind turbine systems, IEEE Transactions on Power Electronics, 19, 1242-1249, 2004.
2. Abdullah MA, Yatim AHM. & Tan CW, An online optimum-relation-based maximum power point tracking algorithm for wind energy conversion

system, Australasian Universities Power Engineering Conference (AUPEC), Australia, 1-6, 2014.
3. Urtasun A, Sanchis P and Marroyo L, Small wind turbine sensorless MPPT robustness analysis and lossless approach, IEEE Transactions on Industry Applications, vol. 50, pp. 4113-4121,Nov. 2014.
4. Yan R, Masood N, Saha TK, A new tool to estimate maximum wind power penetration level: In perspective of frequency response adequacy, Applied Energy, vol. 154, pp. 209–220, Sep 2015.
5. Hui J, Bakhshai A, Jain P, A sensor-less adaptive maximum power point extraction method with voltage feedback control for small wind turbines in off-grid applications, IEEE Journal Emerging on Selected Topic of Power Electronics, vol. 3,pp.817-828,Sep. 2015.
6. Abad G, López J, Rodríguez M, Marroyo L, Iwanski G, Doubly Fed Induction Machine, Modeling and Control for Wind Energy Generation, IEEE Press Series on Power Engineering, Wiley Publications, 2011.
7. Tanaka T, Toumiya T and Suzuki T, "Output control by hill-climbing method for a small scale wind power generating system", Renewable Energy, vol. 12, pp.387-400, December 1997.
8. Mendis N, Muttaqi KM, Sayeef S and Perera S, "Standalone operation of wind turbine-based variable speed generators with maximum power extraction capability", IEEE Transactions on Energy Conversion, vol. 27, no. 4, December 2012.
9. Xiong P and Sun D, "Backstepping-based DPC strategy of a wind turbine-driven DFIG under normal and harmonic grid voltage", IEEE Transaction on Power Electronics, vol. 31, pp. 4216-4225, June 2016.
10. Azzouz M, Elshafei AI and Emara H, "Evaluation of fuzzy-based maximum power-tracking in wind energy conversion systems", IET Renewable Power Generation, vol. 5, pp.422-430, Nov. 2011.
11. Chen SZ, Cheung NC, Wong KC and Wu J, "Integral sliding-mode direct torque control of doubly-fed induction generators under unbalanced grid voltage", IEEE Transactions on Energy Conversion, vol. 25, pp. 356-368, June 2010.
12. Sam SZ and Angel TS, "Performance optimization of PID controllers using fuzzy logic," 2017 IEEE International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), 2017, pp. 438-442, doi: 10.1109/ICSTM.2017.8089200.
13. Li H, Shi KL, McLaren PC, "Neural-network-based sensorless maximum wind energy capture with compensated power coefficient", IEEE Transactions on Industry Applications, vol. 41, no. 6, Dec. 2005.
14. Jabr HM, Lu D and Kar NC, "Design and implementation of neuro-fuzzy vector control for wind-driven doubly-fed induction generator", IEEE Transactions on Sustainable Energy, vol. 2, no. 4,pp. 404-413, October 2011.
15. Amin IK, Uddin MN and Marsadek M, "ANFIS based Neuro-Fuzzy Control of DFIG for Wind Power Generation in Standalone Mode," 2019 IEEE International Electric Machines & Drives Conference (IEMDC), 2019, pp. 2077-2082, doi: 10.1109/IEMDC.2019.8785334.
16. Vrionis TD, Koutiva XI and Vovos NA, "A Genetic Algorithm-Based Low Voltage Ride-Through Control Strategy for Grid Connected Doubly Fed Induction Wind Generators," in IEEE Transactions on Power Systems, vol. 29, no. 3, pp. 1325-1334, May 2014, doi: 10.1109/TPWRS.2013.2290622.
17. Labdai S, Hemici B, Nezli L, Bounar N, Boulkroune A and Chrifi-Alaoui L, "Control of a DFIG Based WECS with Optimized PI controllers via a duplicate PSO algorithm," 2019 International Conference on Control, Automation and Diagnosis (ICCAD), 2019, pp. 1-6, doi: 10.1109/ICCAD46983.2019.9037879.
18. Heydari A, Garcia DA, Fekih A, Keynia F, TjernbergLB and De Santoli L, "A Hybrid Intelligent Model for the Condition Monitoring and Diagnostics of Wind Turbines Gearbox," in IEEE Access, vol. 9, pp. 89878-89890, 2021, doi: 10.1109/ACCESS.2021.3090434.
19. Uddin MN, Amin IK, Rezaei N and Marsadek M, "Grey Wolf Optimization based Power Management Strategy for Battery Storage of DFIG-WECS in Standalone Operating Mode," 2018 IEEE Industry Applications Society Annual Meeting (IAS), 2018, pp. 1-7, doi: 10.1109/IAS.2018.8544633.
20. Jang JSR., Sun CT, and Mizutani E, Neuro-fuzzy and soft computing: a computational approach to learning and machine intelligence, Upper Saddle River, NJ: Prentice Hall, 1997.
21. Karray F and deSilver C, Soft computing and intelligent systems design: theory, tools, and applications, Pearson Publishing Inc., 2004.
22. Chy MMI, Uddin MN, "Development and implementation of a new adaptive intelligent speed controller for IPMSM drive" IEEE Transactions on Industry Applications", vol. 45, no. 3, pp. 1106-115, May-June 2009.
23. Amin IK, Robust Control Techniques for DFIG Driven WECS with Improved Efficiency, PhD dissertation, Dept. of Electrical Engineering, Lakehead University, Thunder Bay, ON, Canada, 2019.
24. Amin IK and Uddin MN, "Nonlinear Control Operation of DFIG-Based WECS Incorporated With Machine Loss Reduction Scheme," in IEEE Transactions on Power Electronics, vol. 35, no. 7, pp. 7031-7044, July 2020, doi: 10.1109/TPEL.2019.2955021.

Global Journals Guidelines Handbook 2022

www.GlobalJournals.org

Memberships

FELLOWS/ASSOCIATES OF ENGINEERING RESEARCH COUNCIL

FERC/AERC MEMBERSHIPS

Introduction

FERC/AERC is the most prestigious membership of Global Journals accredited by Open Association of Research Society, U.S.A (OARS). The credentials of Fellow and Associate designations signify that the researcher has gained the knowledge of the fundamental and high-level concepts, and is a subject matter expert, proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice. The credentials are designated only to the researchers, scientists, and professionals that have been selected by a rigorous process by our Editorial Board and Management Board.

Associates of FERC/AERC are scientists and researchers from around the world are working on projects/researches that have huge potentials. Members support Global Journals' mission to advance technology for humanity and the profession.

FERC

FELLOW OF ENGINEERING RESEARCH COUNCIL

FELLOW OF ENGINEERING RESEARCH COUNCIL is the most prestigious membership of Global Journals. It is an award and membership granted to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Fellows are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Fellow Members.

Benefit

To the institution

Get letter of appreciation

Global Journals sends a letter of appreciation of author to the Dean or CEO of the University or Company of which author is a part, signed by editor in chief or chief author.

Exclusive Network

Get access to a closed network

A FERC member gets access to a closed network of Tier 1 researchers and scientists with direct communication channel through our website. Fellows can reach out to other members or researchers directly. They should also be open to reaching out by other.

Career | Credibility | Exclusive | Reputation

Certificate

Certificate, LoR and Laser-Momento

Fellows receive a printed copy of a certificate signed by our Chief Author that may be used for academic purposes and a personal recommendation letter to the dean of member's university.

Career | Credibility | Exclusive | Reputation

Designation

Get honored title of membership

Fellows can use the honored title of membership. The “FERC” is an honored title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FERC or William Walldroff, M.S., FERC.

Career | Credibility | Exclusive | Reputation

Recognition on the Platform

Better visibility and citation

All the Fellow members of FERC get a badge of "Leading Member of Global Journals" on the Research Community that distinguishes them from others. Additionally, the profile is also partially maintained by our team for better visibility and citation. All fellows get a dedicated page on the website with their biography.

Career | Credibility | Reputation

Future Work

Get discounts on the future publications

Fellows receive discounts on the future publications with Global Journals up to 60%. Through our recommendation programs, members also receive discounts on publications made with OARS affiliated organizations.

Career Financial

GJ Account

Unlimited forward of Emails

Fellows get secure and fast GJ work emails with unlimited storage of emails that they may use them as their primary email. For example, john [AT] globaljournals [DOT] org.

Career Credibility Reputation

Premium Tools

Access to all the Premium Tools

To take future researches to the zenith, fellows receive access to all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Financial

Conferences & Events

Organize seminar/conference

Fellows are authorized to organize symposium/seminar/conference on behalf of Global Journal Incorporation (USA). They can also participate in the same 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. Additionally, they get free research conferences (and others) alerts.

Career Credibility Financial

Early Invitations

Early invitations to all the symposiums, seminars, conferences

All fellows receive the early invitations to all the symposiums, seminars, conferences and webinars hosted by Global Journals in their subject.

Exclusive

Publishing Articles & Books

Earn 60% of sales proceeds

Fellows can publish articles (limited) without any fees. Also, they can earn up to 70% of sales proceeds from the sale of reference/review books/literature/publishing of research paper. The FERC member can decide its price and we can help in making the right decision.

Exclusive Financial

Reviewers

Get a remuneration of 15% of author fees

Fellow members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

Access to Editorial Board

Become a member of the Editorial Board

Fellows may join as a member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. Additionally, Fellows get a chance to nominate other members for Editorial Board.

Career Credibility Exclusive Reputation

And Much More

Get access to scientific museums and observatories across the globe

All members get access to 5 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 10 GB free secure cloud access for storing research files.

ASSOCIATE OF ENGINEERING RESEARCH COUNCIL

ASSOCIATE OF ENGINEERING RESEARCH COUNCIL is the membership of Global Journals awarded to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

> The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Associate membership can later be promoted to Fellow Membership. Associates are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Associate Members.

Benefit

To the institution

Get letter of appreciation

Global Journals sends a letter of appreciation of author to the Dean or CEO of the University or Company of which author is a part, signed by editor in chief or chief author.

Exclusive Network

Get access to a closed network

A AERC member gets access to a closed network of Tier 1 researchers and scientists with direct communication channel through our website. Associates can reach out to other members or researchers directly. They should also be open to reaching out by other.

Career | Credibility | Exclusive | Reputation

Certificate

Certificate, LoR and Laser-Momento

Associates receive a printed copy of a certificate signed by our Chief Author that may be used for academic purposes and a personal recommendation letter to the dean of member's university.

Career | Credibility | Exclusive | Reputation

Designation

Get honored title of membership

Associates can use the honored title of membership. The “AERC” is an honored title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., AERC or William Walldroff, M.S., AERC.

Career | Credibility | Exclusive | Reputation

Recognition on the Platform

Better visibility and citation

All the Associate members of AERC get a badge of "Leading Member of Global Journals" on the Research Community that distinguishes them from others. Additionally, the profile is also partially maintained by our team for better visibility and citation. All associates get a dedicated page on the website with their biography.

Career | Credibility | Reputation

Future Work

Get discounts on the future publications

Associates receive discounts on the future publications with Global Journals up to 60%. Through our recommendation programs, members also receive discounts on publications made with OARS affiliated organizations.

Career | Financial

GJ Account

Unlimited forward of Emails

Associates get secure and fast GJ work emails with unlimited storage of emails that they may use them as their primary email. For example, john [AT] globaljournals [DOT] org..

Career | Credibility | Reputation

Premium Tools

Access to all the premium tools

To take future researches to the zenith, associates receive access to all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Financial

Conferences & Events

Organize seminar/conference

Associates are authorized to organize symposium/seminar/conference on behalf of Global Journal Incorporation (USA). They can also participate in the same 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. Additionally, they get free research conferences (and others) alerts.

Career | Credibility | Financial

Early Invitations

Early invitations to all the symposiums, seminars, conferences

All associates receive the early invitations to all the symposiums, seminars, conferences and webinars hosted by Global Journals in their subject.

Exclusive

Publishing Articles & Books

Earn 30-40% of sales proceeds

Associates can publish articles (limited) without any fees. Also, they can earn up to 30-40% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.

Exclusive | Financial

Reviewers

Get a remuneration of 15% of author fees

Associate members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

And Much More

Get access to scientific museums and observatories across the globe

All members get access to 2 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 5 GB free secure cloud access for storing research files.

Associate	Fellow	Research Group	Basic
$4800 **lifetime designation**	$6800 **lifetime designation**	$12500.00 **organizational**	APC **per article**
Certificate, LoR and Momento 2 discounted publishing/year **Gradation** of Research 10 research contacts/day **1 GB** Cloud Storage **GJ** Community Access	**Certificate,** LoR and Momento **Unlimited** discounted publishing/year **Gradation** of Research **Unlimited** research contacts/day **5 GB** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**Certificates,** LoRs and Momentos **Unlimited** free publishing/year **Gradation** of Research **Unlimited** research contacts/day **Unlimited** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**GJ** Community Access

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

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

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

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

Before and during Submission

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

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

Declaration of Conflicts of Interest

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

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

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

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

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

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

Authorship Policies

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

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

Changes in Authorship

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

Copyright

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

Appealing Decisions

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

Acknowledgments

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

Declaration of funding sources

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

Preparing your Manuscript

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

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

Manuscript Style Instruction (Optional)

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

Structure and Format of Manuscript

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

A research paper must include:

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

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

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

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

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

Format Structure

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

All manuscripts submitted to Global Journals should include:

Title

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

Author details

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

Abstract

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

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

Keywords

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

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

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

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

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

Numerical Methods

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

Abbreviations

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

Formulas and equations

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

Tables, Figures, and Figure Legends

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

Figures

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

Preparation of Eletronic Figures for Publication

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

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

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

Tips for Writing a Good Quality Engineering Research Paper

Techniques for writing a good quality engineering research paper:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Informal Guidelines of Research Paper Writing

Key points to remember:

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

Final points:

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

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

The discussion section:

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

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

General style:

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

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

Mistakes to avoid:

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

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

Title page:

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

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

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

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

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

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

Approach:

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

Introduction:

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

The following approach can create a valuable beginning:

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

Approach:

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

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

Procedures (methods and materials):

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

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

Materials:

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

Methods:

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

Approach:

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

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

What to keep away from:

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

Results:

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

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

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

Content:

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

What to stay away from:

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

Approach:

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

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

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

Figures and tables:

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

Discussion:

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

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

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

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

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

Approach:

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

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

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

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

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

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

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

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

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

INDEX

save our planet

Global Journal of Researches in Engineering

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

ISSN 9755861