



# An analytical and FEM simulation-based study of the dependence of capacitance profile on structural parameters of CMUT with and without vent

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Received: 14 March 2023 / Accepted: 19 September 2023

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## Abstract

This paper presents the capacitive behaviour of a Capacitive Micromachined Ultrasound Transducer (CMUT). A Finite Element Method (FEM)-based simulation is proposed to characterize the capacitance of CMUT with different geometrical parameters. The structure of the CMUT under scrutiny consists of an aluminum top electrode on a thin movable membrane of silicon nitride ( $\text{Si}_3\text{N}_4$ ) separated by an air gap from the bottom electrode. The capacitance of the CMUT plays an important role in its proper functionality. The current study attempts to explore the calculation and variation of capacitance with different geometrical parameters. Because of the smaller dimension of the device, the effect of fringing is also taken into account. A new empirical formulation has been developed to study the capacitance of the CMUT with vented cavities, and the accuracy of the theory is justified with FEM simulation for single-vented CMUT. The analytical results are validated with simulation and published experimental results. Keeping the similar geometrical shape of the fabricated structure, this model predicts 94.28 kHz resonant frequency which is very close to the experimental result (106 kHz).

## 1 Introduction

Since the inception of the concept of CMUT (Hunt 2014; Khuri-Yakub et al. 1988), it outruns its ancestors like Piezoelectric Micromachine Ultrasound Transducer (PMUT) (Pappalardo et al. 2008; Salim et al. 2012; Wong et al. 2007), in most of the aspects, especially in its application in medical field (Jin et al. 1998; Wang et al. 2020) and pressure sensor (Wang et al. 2016). The CMUT consists of two electrodes facing each other, one of which is stationary while the other is flexible and mounted on a thin insulation membrane. An air-sealed gap and an

insulating layer separate the two electrodes. Through the vibration of the membrane, CMUTs can work in transmitting and receiving modes, transforming electrical energy into sound waves or vice versa (Anbalagan et al. 2006).

The CMUT, as the name implies, works on the basis of variation of capacitance of parallel plate capacitors (Ergun et al. 2003). Pirouz et al. have calculated the capacitance of a CMUT theoretically to measure the energy conversion during large signal operation. While doing so, they calculated the capacitance using the inverse Fourier transform of the source impedance (Pirouz & Degertekin 2019). Rahman and Chowdhury developed an approximate method to evaluate the capacitance of a parallel plate capacitor with a square diaphragm (Rahman and Chowdhury 2011) using a deflection shape function. They demonstrated that the contribution of fringing field capacitance cannot be ignored when the dimension of the diaphragm is small (fringing capacitance is 9% for square diaphragms with a side length of 100  $\mu\text{m}$  and air gap 3  $\mu\text{m}$ ). While calculating the non-linear lumped equivalent circuit model of a CMUT with square diaphragm, Mohammad Maadi et al. demonstrated a method to evaluate the total capacitance of deflected diaphragm with the full electrode (Maadi and Zemp 2019). A rigorous analytical method of calculation of fringing field

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# Effect of heavy metal and alkaline earth oxides on the optical and electrical mechanism of vanadium-phosphate amorphous glassy systems

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## ARTICLE INFO

### Keywords:

Oxide glass  
Optical bandgap  
Urbach energy  
AC conductivity  
CBH model

## ABSTRACT

In the current work, the collective effects of the doping of heavy metal oxide ( $\text{Bi}_2\text{O}_3$ ) and alkaline metal oxide ( $\text{BaO}$ ) into the host glassy network having chemical formula  $x\text{Bi}_2\text{O}_3 \cdot (0.4-x)\text{BaO} \cdot 0.3\text{V}_2\text{O}_5 \cdot 0.3\text{P}_2\text{O}_5$  ( $x = 0.05, 0.15, 0.25, \text{ and } 0.35$ ) are studied systematically. The X-ray diffraction reveals the amorphous nature of the composites under study. Physical properties like density and molar volume have been investigated and correlated with structural modifications. The findings of Tauc's plot have confirmed the increment in optical band gap energies from 2.81 eV to 3.51 eV and correlated with the decrement of Urbach energy values. Some spectroscopic parameters like refractive index, reflectivity, reflection factor, and non-linear refractive index have been examined and interpreted accordingly. The mechanism is accountable for AC conductivity has been inspected using Almond-West formalism and Jonscher's universal power law, revealing semiconducting features. The small polaron hopping route with various activation energies at numerous temperature ranges causes non-linearity in DC conductivity in all of the studied samples.

## 1. Introduction

Vanadate glasses with significant concentrations of  $\text{V}_2\text{O}_5$  are composed of multivalent ions of various states. Both atomic-exchange electroconductive and infrared transmission glasses, which utilise electron conduction, are manufactured with this material [1]. Vanadium pentoxides ( $\text{V}_2\text{O}_5$ ) have a wide range of applications, including thin-film batteries, infrared detectors, electrochromic devices, electrochemical capacitors, chemical sensors, and so on [2]. Because vanadates have bipyramidal, polyhedral, and octahedral coordination environments, they can take on many structural forms in various oxidation states, attracting a lot of attention [3,4]. They have possessed optical and electrical properties due to the creation of  $\text{V}_2\text{O}_5$  layered structures within the compositions [5]. The structural behaviour of  $\text{V}_2\text{O}_5$  doped glasses shows the presence of the  $\text{VO}_4^{3-}$  group, where the  $\text{V}^{5+}$  ion is bound in tetrahedral symmetry to four  $\text{O}^{2-}$  ions [6]. The vanadate glassy

system is also composed of a layered chain of  $\text{VO}_4$  polyhedron units [7]. Phosphate-based glasses are significant technological materials. They have excellent physical features compared to other glasses [8].  $\text{PO}_4$  tetrahedra framework is linked with P–O–P bridges that form chains, rings, or single  $\text{PO}_4$  groups, providing the foundation for the network of phosphate glasses [9]. P–O groups in phosphate glasses are unaffected by modifying cations when introduced and depolymerization only occurs when bonds are broken. The incorporation of transition metal oxides (TMOs), like  $\text{V}_2\text{O}_5$ , on the other hand, causes depolymerization to produce P–O–TM bonds, which alters the physical properties of these glasses [10,11]. The most noticeable properties of vanadium phosphate glasses are at low-temperature regions, where the DC conductivity activation energy is found to depend on temperature, and AC conductivity shows nearly a linear function of frequency [12]. The conduction process is governed by the small polaron hopping in the transition metal ion sites [13,14]. The alkaline earth oxides CaO, SrO, and BaO have

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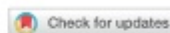
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<https://doi.org/10.1016/j.jnoncrsol.2023.122593>

Received 28 May 2023; Received in revised form 18 August 2023; Accepted 20 August 2023

Available online 29 August 2023

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# Progressive effect of dual-hybridization in friction stir welding by ultrasonic vibration and resistive heating for joining dissimilar material Al6063 aluminium alloy and C26000 copper alloy

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## ABSTRACT

In the world of disruptive technology, Al–Cu joints are quite in demand for electric vehicle batteries and other ion battery applications. Fusion welding is the less preferred method due to its many disadvantages; friction stir welding has the potential to become a sustainable process for producing a sound dissimilar Al–Cu joint. A study of multiple hybridization to the Friction Stir Welding (FSW) was made by utilizing two different energy sources of ultrasonic energy and electric current. The improvement is the property by different combination of the hybridization studied for utilizing the multiple hybridization technique to the FSW process for improving the weld efficacy and defects free weld even in case of dissimilar joints. Mechanical properties obtained by varying the process parameters have been studied and compared. Three process parameters have been selected including ultrasonic energy (10KHz), electric current (75–125 Amps), rpm (400–600rpm) and transverse tool rate (30–50 mm/min). A remarkable improvement in the mechanical property has been monitored by adding electric current to the UAFSW. Similar optimistic results in the improvement of the property have been found by adding Ultrasonic energy to RHFSW. The comparative study in the mechanical property had been presented to explain the improvement in the weld efficacy.

**Nomenclature and Abbreviations:** FSW: Friction stir welding; RHFSW: Resistive heating assisted friction stir welding; UAFSW: Ultrasonic assisted friction stir welding; DURHFSW: Dual ultrasonic and resistive heating assisted friction stir welding; UV: Ultrasonic vibration; SZ: Stir zone

## ARTICLE HISTORY

Received 2 December 2023

Revised 8 May 2024

Accepted 17 May 2024

## KEYWORDS

Ultrasonic assisted friction stir welding; resistive heating assisted friction stir welding; electric assisted friction stir welding; multiple hybridization; Al alloy; copper



# Effect of heavy metal and alkaline earth oxides on the optical and electrical mechanism of vanadium-phosphate amorphous glassy systems

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## 1. Introduction

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system is also composed of a layered chain of  $\text{VO}_4$  polyhedron units [7]. Phosphate-based glasses are significant technological materials. They have excellent physical features compared to other glasses [8].  $\text{PO}_4$  tetrahedra framework is linked with P–O–P bridges that form chains, rings, or single  $\text{PO}_4$  groups, providing the foundation for the network of phosphate glasses [9]. P–O groups in phosphate glasses are unaffected by modifying cations when introduced and depolymerization only occurs when bonds are broken. The incorporation of transition metal oxides (TMOs), like  $\text{V}_2\text{O}_5$ , on the other hand, causes depolymerization to produce P–O–TM bonds, which alters the physical properties of these glasses [10,11]. The most noticeable properties of vanadium phosphate glasses are at low-temperature regions, where the DC conductivity activation energy is found to depend on temperature, and AC conductivity shows nearly a linear function of frequency [12]. The conduction process is governed by the small polaron hopping in the transition metal ion sites [13,14]. The alkaline earth oxides CaO, SrO, and BaO have

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<https://doi.org/10.1016/j.jnoncrsol.2023.122593>

Received 28 May 2023; Received in revised form 18 August 2023; Accepted 20 August 2023

Available online 29 August 2023

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# Effect of heavy metal oxide and alkaline earth oxide on optical, and electrical properties of tellurite-phosphate glass composites

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## ARTICLE INFO

### Keywords:

Quaternary glass composites

XRD

Optical bandgap energy

AC and DC conductivity

Modified CBH model

## ABSTRACT

In the present report, the combined effects of the incorporation of  $\text{Bi}_2\text{O}_3$  and  $\text{BaO}$  into the host glassy network of chemical formula  $x\text{Bi}_2\text{O}_3 \cdot (0.4-x)\text{BaO} \cdot 0.25\text{TeO}_2 \cdot 0.35\text{P}_2\text{O}_5$  ( $x = 0, 0.05, 0.15$ , and  $0.20$ ) are studied. The X-ray diffraction reveals some nanophases like  $\text{Ba}_3\text{Te}_2\text{O}_6$ ,  $\text{BaTeO}_3$ ,  $\text{Ba}_3\text{Te}_4\text{O}_{11}$ ,  $\text{BaTeO}_3$ ,  $\text{Ba}_2\text{P}_2\text{O}_7$ ,  $\text{Ba}_3(\text{PO}_4)_2$ ,  $\text{Ba}_3(\text{PO}_4)_2$ ,  $\text{BaO}_2$  are superimposed within the synthesized glassy matrices. The SEM images reveal fine crystallite particles are dispersed randomly throughout the matrix in a localized colony-like arrangement, and EDX spectra indicate the weight and atomic percentage of each constituent element. Analysis of Raman spectra confirms various band formations. Density, molar volume and other physical properties have been correlated with structural modifications. Tauc's plot confirms the decrement in optical band gap energies from 3.91 eV to 3.40 eV, conversely, the Urbach energy values increase from 0.53 eV to 0.69 eV. The absorption coefficient, extinction coefficient, and refractive index have been examined and interpreted accordingly. The well-known Wemple Di Domenico (WDD) model has been deployed to analyse the dispersive parameters. The Almond–West formalism is used to study the electrical conductivity of all glass nanocomposite samples. The modified correlated barrier-hopping (CBH) model explains the AC conductivity mechanism. The semiconducting non-linear characteristic is conspicuously observed from the DC conductivity spectra.

## 1. Introduction

Due to their distinctive morphological and optical characteristics, as well as their capacity to effortlessly synthesize a wide range of compositions, glassy materials are the most promising ones to meet contemporary breakthrough expectations in technology. Glasses are considered to be the most effective inorganic materials used to manufacture sophisticated photonic devices due to their high transparency, high doping capacity, low manufacturing costs, and ease of synthesis in a range of

sizes and shapes [1,2]. Phosphate glasses have gained a great deal of attention and have undergone extensive study as a result of their exceptional transparency and low melting temperature [1,2]. Phosphate glasses possess restricted chemical stability and a significant hygroscopic nature as a result of the presence of hygroscopic P—O—P bonds, which typically restricts their application [3]. However, by incorporating heavy metal oxides ( $\text{Bi}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{TiO}_2$ , etc.) or modifier oxides ( $\text{BaO}$ ,  $\text{Na}_2\text{O}$ ,  $\text{Li}_2\text{O}$ , etc.) within the phosphate glass network, this drawback may be overcome. While these oxides are incorporated, the

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<https://doi.org/10.1016/j.jnoncrsol.2024.122976>

Received 11 December 2023; Received in revised form 2 April 2024; Accepted 13 April 2024

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# Photocatalytic degradation of Rhodamine B dye via Bi<sub>2</sub>O<sub>3</sub> embedded BaO-P<sub>2</sub>O<sub>5</sub>-TeO<sub>2</sub> glass nanocomposites: An ab initio study of structural, optical, and electrical transport properties

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## ARTICLE INFO

### Keywords:

Photocatalytic activity  
Rhodamine B dye  
Optical band gap energy  
Mott and Greaves's model

## ABSTRACT

Bismuth incorporated glassy systems with composition  $x\text{Bi}_2\text{O}_3-(1-x)[0.3\text{BaO}-0.3\text{P}_2\text{O}_5-0.4\text{TeO}_2]$  (where  $x = 0.10, 0.15, 0.20, \text{ and } 0.25$ ) are synthesized by melt quenching technique. The glassy systems are examined for their structural, and surface morphological properties using XRD, SEM, and EDX analysis. A study of photocatalytic activity for the degradation of common organic dyes like Rhodamine B (RhB) dye under visible light is also carried out. From UV-vis absorbance data, the calculated optical band gap energy values declined from (2.99–2.56) eV, whereas the Urbach energy and refractive index values increased from (0.35–0.52) eV, and (2.39–2.52), respectively with the rise of Bi<sub>2</sub>O<sub>3</sub> content( $x$ ). Additionally, the fundamental processes of electrical conductivity have been studied within the framework of Jonscher's universal power law and the Almond-West formalism. The Mott and Greaves model asserts that the small polaron hopping model underlies DC conductivity; as Bi<sub>2</sub>O<sub>3</sub> content increases, DC conductivity rises, but hopping distance ( $R_{\text{hop}}$ ) and hopping energy ( $W_{\text{hop}}$ ) drop dramatically. The electrical conductivity study reveals the semi-conducting nature of the as-prepared samples. In our present study, we are focusing on the structural, optical, and electrical transportation properties, additionally, we investigated this class of glassy materials as a promising candidate for photocatalytic dye degradation. Our study reveals that RhB dye can degrade up to 75% within 340 min of visible light illumination. Moreover, the test demonstrates the production of superoxide radicals by the CB-electrons and hydroxyl radicals by the VB holes enables efficient photocatalytic dye degradation.

## 1. Introduction

In the scientific realm of materials science, the pursuit of novel compositions and structures has led researchers to explore cutting-edge solutions for enhancing the performance and versatility of optical materials. Telluride glasses, characterized by their unique infrared transmission properties, have emerged as promising candidates for numerous applications, ranging from telecommunications to infrared imaging [1–3]. The BaO-P<sub>2</sub>O<sub>5</sub>-TeO<sub>2</sub> glass matrix, a ternary system composed of barium oxide (BaO), phosphorus pentoxide (P<sub>2</sub>O<sub>5</sub>), and tellurium dioxide (TeO<sub>2</sub>), emerges as a significant subject within modern materials science owing to its distinctive combination of optical, photocatalytic, and electrical attributes [4–6]. This distinct combination is important for

its potential applications in optical devices, infrared technologies, and organic dye-degradation. The significant oxidizing potential of the hydroxyl radicals emitted during the photocatalytic process renders photocatalytic degradation a useful approach for the substances [7,8].

In addition to photocatalytic properties, the high refractive indices of the BaO-P<sub>2</sub>O<sub>5</sub>-TeO<sub>2</sub> glass matrix contribute to its efficacy in manipulating light, making it particularly advantageous for optical applications [9]. Furthermore, the superior transparency within the infrared spectrum enhances its suitability for deployment in technologies reliant on infrared radiation. These inherent characteristics not only make the glass matrix versatile in optical devices like lenses and optical fibers but also underscore its potential in infrared sensors and electronic components [10]. Consequently, the BaO-P<sub>2</sub>O<sub>5</sub>-TeO<sub>2</sub> glass matrix emerges as a

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<https://doi.org/10.1016/j.jnoncrysol.2024.123034>

Received 12 March 2024; Received in revised form 10 May 2024; Accepted 16 May 2024

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# Development of an interactive GUI using MATLAB for the detection of type and stage of Breast Tumor

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**Abstract**— Breast cancer is described as one of the most common types of cancer which has been diagnosed mainly in women. When compared in the ratio of male to female, it has been duly found that the prone of having breast cancer is more in females than males. Breast lumps are classified mainly into two groups namely: cancerous and non-cancerous. When we say that the lump in the breast is cancerous, it means that it can spread via lobules, ducts, areola, stroma to various organs of the body. On the other hand, non-cancerous breast lumps are less harmful but it should be monitored under proper diagnosis to avoid it being transformed to cancerous lump. To diagnose these breast lumps the method of mammogram, ultrasonic images and MRI images are undertaken. Also, for better diagnosis sometimes doctors recommend for biopsy and any unforeseen anomalies occurring there may give rise to inaccurate test report. To avoid these discrepancies, processing the mammogram images is considered to be one of the most reliable methods. In the proposed method MATLAB GUI is developed and some sample images of breast lumps are placed accordingly in the respective axes. With the help of sliders the actual breast lump image is compared with the already stored breast lump sample images and then accordingly the history of the breast lumps is generated in real time in the form of test report.

**Keywords**—mammogram; MATLAB GUI; biopsy; breast tumor; cancerous.

## I. INTRODUCTION

Cancer or carcinoma is very common now-a-days. From Dr. Mary Ling's (Breast & General Surgeon) webpage, it is known that the part of the breast which produces milk is divided into 15-20 sections which are known as

*lobes*. The ducts are the network of tiny tube through which milk travels which eventually exit the skin of the breast nipples. The areola is the dark area of the skin which surrounds the nipple portion. To provide the shape to the breast, the connective tissues and ligaments play an important role. The nerves in the breast provide the sensation. From Ann Pietrangelo's documentation in Healthline webpage, the early signs and symptoms of breast cancer are described as (a) development of a new lump in the region of breast or armpit, (b) feeling of swelling in some parts of the breast, (c) rashes and irritation occurs in the nipple area, (d) feeling of pain in any part of the breast, (e) changes is observed in the shape and size of the breast, (f) discharge of a fluid from the nipple apart from the breast milk.

A mass in Breast may occur due to abnormal cell division. There are basically two types of mass or breast tumors as follows:

**Benign tumors:** According to National Breast Cancer Foundation INC, when a tumor is diagnosed as non-spreading, doctors usually keep as it is rather than attempting to remove it. Though these tumors are not that alarming toward surrounding tissue, sometimes they may continue to spread towards the tissues and when any pain or other problem arises the tumor is removed, thus relieving the patient from pain or complications.

**Malignant tumors:** Malignant tumors are cancerous and may be dangerous because they enter and damage the surrounding tissues. According to National Breast Cancer Foundation INC, when a malignant tumor is found then the doctors advice to perform a biopsy to understand how severe the tumor is. In a human body, when the proto oncogene is activated and converted into oncogene then there is growth of cancerous cell. There are many reasons that are responsible for the conversion of proto oncogene to oncogene (heredity, gene mutation

# Efficient selfish node detection using SVM in IoT-MANET environment

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## Abstract

The communication between nodes in the Internet of Things-based mobile ad-hoc networks environment is typically dependent on their selfless attitude. Whenever a node needs to send a message to another node in the network, it needs the help of one or more nodes to act as a router(s) that will bridge the gap between the source and the destination. All these selfless forwarding's require energy, bandwidth, and other resources. Therefore, some routers often raise a link breakage attack to save their resources. They keep silent after receiving a message; neither they acknowledge it nor they forward it. These selfish nodes must be identified and carefully avoided while choosing routes; otherwise, numerous messages will have to be resent, including control messages like route-request. The identification depends on the past behavior of the node as well as velocity, the direction of movement, current geographical location and so forth. This article presents a support vector machine-based node classification method that checks whether nodes are intentionally issuing a link breakage attack or it is really out of the radio range of its predecessor. The simulation results of the proposed method demonstrate that the proposed technique can correctly detect most of the selfish activities in the network and that also in much lesser time. It also enhances the packet delivery ratio and reduces delay and energy consumption.

## 1 | INTRODUCTION

A mobile ad-hoc network (MANET) consists of multiple battery-powered nodes that exchange messages with each other either directly or indirectly with the help of some router nodes, which bridge the gap between a predefined sender and receiver. Since these networks do not require any existing infrastructure or centralized administration, they are suitable for deployment for group-wise independent communications in the Internet of Things (IoT).<sup>1-4</sup> This IoT-MANET



# Effect of the inclusion of $\text{Fe}_2\text{O}_3$ on the optical and electrical transport properties into sodium-zinc-phosphate quaternary glassy systems

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## ARTICLE INFO

### Keywords:

Glasses  
XRD  
FTIR  
Optical Properties  
Electrical transport Properties

## ABSTRACT

Glass systems,  $x\text{Fe}_2\text{O}_3-(35-x)\text{Na}_2\text{O}-25\text{ZnO}-40\text{P}_2\text{O}_5$  ( $x = 10, 15, 20$ , and  $25$  mol%), were prepared using the melt-quenching technique. FTIR analysis revealed stretching vibrations of the P–O–P and P–O bonds and XRD investigation revealed a pure amorphous structure. It was discovered that with rising  $\text{Fe}_2\text{O}_3$  content ( $x$ ), the values of density increased, but the values of molar volume decreased. The  $\text{Fe}_2\text{O}_3$  incorporation into the glass matrix resulted in decrement in the optical band gap energy ( $E_{\text{opt}}$ ) value from 2.99 to 2.16 eV. The addition of  $\text{Fe}_2\text{O}_3$  to the glass network reduced the quantity of non-bridging oxygen ions, improving the observed refractive index value. According to the Mott and Greaves model, the small polaron hopping model was responsible for the DC conductivity mechanism, and the density of states at the Fermi level increased as DC conductivity increased with increasing  $\text{Fe}_2\text{O}_3$  content, but hopping distance ( $R_{\text{hop}}$ ) and hopping energy ( $W_{\text{hop}}$ ) sharply decreased. It was concluded that the AC conductivity mechanism followed the correlated barrier hopping model as the power-law exponent ( $s$ ) of Jonscher's universal power law decreased with temperature. AC conductivity increased with rising  $\text{Fe}_2\text{O}_3$  concentration due to a decrement in the polaron hopping distance value and an increment in the concentration of defect pair states.

## 1. Introduction

Phosphate glasses are of enormous technical and scientific importance for theoretical and practical applications such as optics, biomedicine, and electrochemistry as low-temperature sealing glasses and as hosts for nuclear wastes because they have a lower melting point, higher UV transmission and larger thermal expansion coefficient [1–3]. The typical chemical stability of conventional phosphate glasses is relatively low [4], which frequently limits their real-world applications. Numerous studies have demonstrated that adding additional oxides, such as  $\text{Fe}_2\text{O}_3$ ,  $\text{MoO}_3$ ,  $\text{Al}_2\text{O}_3$ , and  $\text{Sb}_2\text{O}_3$ , improves the chemical stability

of phosphate glasses [5–8]. Among them, iron phosphate glasses are becoming more acceptable in a variety of scientific and biomedical fields. Iron phosphate glasses demonstrate high chemical stability because P–O–P bonds have been substituted by moisture-preventive P–O–Fe bonds. Depolymerization of phosphate chains happens after the inclusion of  $\text{Fe}_2\text{O}_3$  into the glass matrices, which assists in controlling these P–O–Fe links [9]. This increased chemical stability modifies the glass transition temperature and incorporates subsequent changes in electronic conductivity, as found in other studies [10,11]. Iron oxide exists in two different states, trivalent ferric ions ( $\text{Fe}^{+3}$ ) and divalent ferrous ions ( $\text{Fe}^{+2}$ ), and it also frequently exhibits electrical conductivity

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<https://doi.org/10.1016/j.mtcomm.2023.107785>

Received 16 September 2023; Received in revised form 21 November 2023; Accepted 2 December 2023

Available online 5 December 2023

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# Effect of the iron content on the thermal and dielectric relaxation process of sodium zinc-phosphate quaternary glassy systems

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## ARTICLE INFO

### Keywords:

Glass transition temperature

Thermal stability

Dielectric properties

Havriliak-Negami formalism

Electric modulus

## ABSTRACT

To explore the consequence of Na<sub>2</sub>O substitution by Fe<sub>2</sub>O<sub>3</sub> on the physical, thermal and dielectric properties of zinc-phosphate-based glassy systems, a series of samples with chemical compositions of 25ZnO-40P<sub>2</sub>O<sub>5</sub>-(35-x)Na<sub>2</sub>O-xFe<sub>2</sub>O<sub>3</sub> where, (x = 0.10, 0.15, 0.20, 0.25) have been prepared by melt quenching technique. The well-known Archimedes principle is deployed to measure the value of densities of the materials. DSC thermographs specify that the glass transition temperature (*T<sub>g</sub>*) declines with the incorporation of Fe<sub>2</sub>O<sub>3</sub> content. While thermal stability increases upon adding the Fe<sub>2</sub>O<sub>3</sub> content. The dielectric constant ( $\epsilon'$ ) and dielectric loss ( $\epsilon''$ ) rise with an increase in temperature and fall as frequency rises sharply. The obtained relaxation time exhibits Arrhenius behaviour, and the dynamic conductivity relaxation process is not of the Debye type because the Kohlrausch stretching exponent ( $\beta$ ) value is not equal to unity. According to the scaled electric modulus (complex) spectra, composition instead of temperature affects the dynamic conductivity relaxation mechanism.

## 1. Introduction

Phosphate glasses are used in a variety of modern applications because of their distinctive and intriguing features, which include higher thermal expansion coefficients, lower melting temperatures, improved electrical conductivities, and unique optical properties [1,2]. These encompass data transmission through optical fibres, laser materials, solid electrolytes, and sealing materials and even go so far as to be used as a host material for the disposal of radioactive wastes [1,3]. The real-world applications of ordinary phosphate glasses are commonly constrained by their typically low chemical stability [4]. Numerous investigations reveal that the chemical stability of phosphate glasses is enhanced by the inclusion of additional oxides such as Fe<sub>2</sub>O<sub>3</sub>, MoO<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, and Sb<sub>2</sub>O<sub>3</sub> [5]. Additionally, it is widely accepted that phosphate glasses may support significant amounts of Transition metal (TM) ions while continuing to be amorphous and exhibit vibrant colours. The

distribution of tetrahedral sites in phosphate glasses is denoted as 'Q<sub>n</sub>'. Here, the value of n indicates the quantity of bridging oxygen (BO) atoms per PO<sub>4</sub> tetrahedron in the phosphate glassy network, varying from zero to three. In addition, modifier oxides, such as some transition metal oxides, facilitate the depolymerization process in the glass network and the creation of non-bridging oxygen atoms (NBO), improving their chemical stability [1].

Glasses made of iron phosphate are becoming more common in many scientific and biomedical areas of study. Because P-O-P links are replaced by P-O-Fe bonds that are more moisture-resistant, iron phosphate glasses exhibit a high level of chemical stability. Fe<sub>2</sub>O<sub>3</sub> is added to the glass matrices to manage these P-O-Fe linkages, resulting in the depolymerisation of phosphate chains [6]. This improved chemical stability alters the glass transition temperature and integrates a subsequent change in electrical conductivity, as seen in earlier research [7,8]. As previously reported [9,10], iron oxide may appear as ferric ions

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# Influence of Sb doping on thermal properties and electrical conductivity mechanism of $\text{Sb}_x\text{Se}_{50-x}\text{Sn}_{20}\text{Te}_{30}$ chalcogenide glassy systems

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## ARTICLE INFO

### Keywords:

DSC  
Kissinger method  
Activation energy  
AC and DC Conductivity  
Mott and Greaves's variable range hopping model  
Pan Ghosh model

## ABSTRACT

Tunability of thermal, and electrical characteristics of  $\text{Sb}_x\text{Se}_{50-x}\text{Sn}_{20}\text{Te}_{30}$  ( $x = 2, 4, 6$ , and  $8$  at. %) bulk glass systems with varying doping concentrations are the major objective of this study. The melt quenching technique has been employed to synthesize the samples. Various thermal parameters have been inspected by using DSC measurements. The effect of Sb addition on the glass transition temperature ( $T_g$ ), crystallization temperature ( $T_c$ ), peak crystallization temperature ( $T_p$ ), and melting temperature ( $T_m$ ) have been observed from DSC thermograms. The dependence of  $T_g$ ,  $T_c$ ,  $T_p$ , and  $T_m$  on the heating rate has been measured. The thermal analysis is performed under non-isothermal conditions at heating rates of  $5, 10, 15$ , and  $20$  K/min. The activation energies for the glass transition temperature are estimated by using the Kissinger method and are found to decrease from  $(211.21-168.85)$  KJ.mol<sup>-1</sup>. Thermal stability and glass forming ability for all glassy compositions have been examined in terms of Hruby's parameter. In addition, electrical conductivity mechanisms over vast temperature and frequency ranges are analyzed. The DC conductivity mechanism has been analyzed by deploying Mott and Greaves's variable range hopping model, while the AC conductivity mechanism has been analyzed by deploying the modified correlated barrier hopping model. AC conductivity scaling property has been examined by using the Pan and Ghosh model. The influence of Sb addition has been observed as the DC and AC conductivity increases with the increase of doping concentration.

## 1. Introduction

Chalcogenide compounds are technologically extremely important because of their fascinating properties, which include lower band gap values, high absorption coefficients, wide transparency in the infrared, high thermal stability, radiation trapping and a wide range of industrial applications [1–3]. In addition, bulk chalcogenide glassy materials are specifically important from a technological standpoint because of their distinctive characteristics, which include the ability to regulate their electrical and optoelectronic properties by varying their composition to suit any potential application [4–6]. Numerous theoretical and experimental studies on the composition, physiology, and spectroscopic

properties of Chalcogenide glasses have been conducted so far. These investigations show that by modifying the composition, the characteristics of Chalcogenide glasses can be improved or fine-tuned [7–10]. It is well known that the incorporation of some additives as doping elements alters the physical, optical, and electrical features of glassy materials. The selenium-doped glasses are recognized as amorphous semi-conductors due to their applicability in numerous technological fields [11–13]. It ought to be noted that pure selenium has certain disadvantages and is not a good solid for producing glasses because of its low thermal stability and brief lifetime. [14]. To circumvent these problems, some other elements like Te are combined with Se, resulting in an increased photosensitivity, and improved thermal stability [15,16]. The

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<https://doi.org/10.1016/j.jnoncrysol.2024.122953>

Received 9 January 2024; Received in revised form 20 March 2024; Accepted 25 March 2024

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# Investigation of the physical, thermal, and dielectric relaxation of bismuth zinc phosphate glasses modified with lithium ions for possible energy storage applications

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Received: 16 February 2024

Accepted: 11 June 2024

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## ABSTRACT

Mixed ionic-electronic  $x\text{Li}_2\text{O}-(1-x)[0.25\text{Bi}_2\text{O}_3-0.35\text{ZnO}-0.30\text{P}_2\text{O}_5]$  ( $x = 0.05, 0.15, 0.25, 0.35$ , and  $0.45$ ) glasses have been formed by melt-quenching procedure to examine their physical, thermal, and dielectric characteristics. The physical investigation exposed that the density decreases from  $5.23$  to  $4.74 \text{ g}\cdot\text{cm}^{-3}$  with the addition of Li-ions into the glassy matrix. Thermal investigations have been carried out using DSC technique. The values of Glass transition temperature ( $368.21$ – $301.65$ ) °C, and peak crystallization temperature ( $561.61$ – $511.21$ ) °C are observed to decrease with the addition of  $\text{Li}_2\text{O}$  content. Conductivity spectra of as-prepared samples have been studied in frequencies ranging from  $20 \text{ Hz}$  to  $2 \text{ MHz}$  temperature range of  $373$ – $513 \text{ K}$ . It becomes apparent that when the temperature rises, the dielectric loss and dielectric constant of the systems under study decrease. The quantities of dielectric loss and dielectric constant are projected to escalate with increasing temperature while diminishing with higher frequencies. The Kohlrausch–Williams–Watts model is employed to analyze the relaxation process in glass samples. This model demonstrates that the charge carriers adhere to non-Debye-type relaxation. Some thermodynamic parameters linked with the dielectric relaxation process have also been investigated. Impedance spectroscopy analysis suggests that electric conduction arises via Li and electrons/polarons, which makes the studied materials appropriate for energy storage applications.

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# Implementation of combined hydrogen aqua electrolyser-fuel cell and redox-flow-battery under restructured situation of AGC employing TSA optimized PDN(FOPI) controller

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## ABSTRACT

This work addresses the automatic-generation-control of multiple-area and sources under a restructured-situation. Sources within area-1 represent geothermal power plant, thermal, and gas, and area-2 sources represent thermal, hydro, and wind. An original endeavour is brought about to execute a controller with an admixture of proportional-derivative with filter (PDN) (integer-order) besides fractional-order proportional-integral (FOPI). Examination manifests excellence of PDN(FOPI) over integer order controllers likely integral, proportional-integral, proportional-integral-derivative-filter from perspective concerning depleted status of peak aberrations, extent-of-oscillations, and duration of settlement. To attain the controller's attributes bioinspired meta-heuristic tunicate swarm algorithm is exercised. The occurrence of renewable sources makes arrangements meaningfully improved related to base thermal-gas-hydro arrangement. The action of hydrogen aqua electrolyzer-fuel cell and redox flow battery is examined using a PDN(FOPI) controller, providing noteworthy outcome in dynamic performance. The analysis is conducted under all the schemes of restructured situations.

## ARTICLE HISTORY

Received 28 December 2022  
Revised 1 February 2024  
Accepted 19 March 2024

## KEYWORDS

Automatic generation control; fuel cell; hydrogen aqua electrolyzer; PDN(FOPI) controller; redox flow battery; tunicate swarm algorithm

## Nomenclature

|                      |                                                                                                    |
|----------------------|----------------------------------------------------------------------------------------------------|
| $I$                  | Subscript refers to area- $i$ ( $i = 1, 2$ ) for two areas                                         |
| $*$                  | Superscript denotes optimum value                                                                  |
| $B_i$                | Frequency bias coefficient of area- $i$                                                            |
| $D_i$                | $\Delta P_{Di} / \Delta f_i$ (p.u. MW/Hz)                                                          |
| $R_i$                | Governor speed regulation parameter of area- $i$ (Hz/p.u. MW)                                      |
| $\beta_i$            | Area frequency response characteristics of area- $i$ ( $= D_i + 1/R_i$ )                           |
| $\Delta P_{Di}$      | Incremental load change in area- $i$ (p.u. MW)                                                     |
| $\Delta P_{gi}$      | Incremental generation change in area- $i$ (p.u. MW)                                               |
| $F$                  | Nominal frequency (Hz)                                                                             |
| $P_i$                | $\pi$                                                                                              |
| $\Delta P_{tie-i-j}$ | Incremental change in tie-line power in the line connecting area- $i$ and area- $j$ ( $i \neq j$ ) |
| $\Delta f_i$         | Deviation in the frequency of area- $i$ (Hz)                                                       |
| $T_{ij}$             | Synchronizing coefficients                                                                         |
| $T$                  | Simulation time (s)                                                                                |
| $H_i$                | Inertia constant of area- $i$ (s)                                                                  |
| $K_{pi}$             | $1/D_i$ (Hz / p.u. MW)                                                                             |
| $T_{pi}$             | $(2 \times H_i) / (f_i \times D_i)$ (s)                                                            |
| $P_{ri}$             | Rated power of area- $i$ (MW)                                                                      |

|           |                                                                              |
|-----------|------------------------------------------------------------------------------|
| $a_{ij}$  | $P_{ri}/P_{rj}$                                                              |
| $N$       | Number of search agents                                                      |
| $T_{gi}$  | Steam governor time constant for thermal power plant of area- $i$ (s)        |
| $T_{ti}$  | Turbine time constant for thermal power plant of area- $i$ (s)               |
| $T_{ri}$  | Reheat turbine time constant for thermal power plant of area- $i$ (s)        |
| $K_{ri}$  | Reheat turbine gain for thermal power plant of area- $i$                     |
| $B_{gi}$  | Time constant of valve position of the gas plant of area- $i$ (s)            |
| $C_{gi}$  | Gas turbine valve position of the gas plant of area- $i$                     |
| $X_{gi}$  | Lead time constant of gas turbine governor of the gas plant of area- $i$ (s) |
| $Y_{gi}$  | Lag time constant of gas turbine governor of the gas plant of area- $i$ (s)  |
| $T_{cri}$ | Gas turbine combustion reaction time delay of the gas plant of area- $i$ (s) |
| $T_{fi}$  | Gas turbine fuel time constant of the gas plant of area- $i$ (s)             |
| $T_{cdi}$ | Compressor discharge volume time constant of the gas plant of area- $i$ (s)  |



# Application of RT-Lab in Multi-Area AGC System under Deregulated Environment Considering IPFC-SMES

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Received: 1 May 2022 / Accepted: 2 June 2021

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## Abstract

This article demonstrates the practice of real-time laboratory (RT-Lab) in hybrid simulations of AGC studies. Investigations determine the optimal location of superconducting magnetic energy storage (SMES) and interline power flow controller (IPFC) in a thermal-reserveable system comprising of realistic dish Stirling system in area-1, 2, and precise wind system in area-3 with the integration of automatic control of high voltage direct current (AHVDC) transmission. In addition, a new cascading controller combining a fractional-order proportional integral and (ii) integral derivative filter (FOPI-TIDFD) and their parameters are enhanced by an empirical genetic algorithm technique considering hybrid peak area integral squared error (HPISE) as a new performance criteria. The superiority of the FOPI-TIDFD controller is evaluated over PI, PD and TIDFD and better dynamics are observed with FOPI-TIDFD. Moreover, system dynamics obtained at optimum gain parameters with HPISE shows superior performance over ISE. Further, the response comparison with RT-Lab shows better dynamics than MATLAB Software responses. The responses of the thermal-reserveable system united with SMES, AHVDC and IPFC show better dynamics over the AC and AC-AHVDC system. Furthermore, investigation suggests the ideal setting of SMES-IPFC to lower frequency areas.

**Keywords** Automatic generation control · HPISE · Parallel AC-AHVDC system · PVTS · RDGTS · IPFI · SMES

## Abbreviations

|         |                                             |
|---------|---------------------------------------------|
| ISE     | Integral squared error                      |
| TS      | Power System                                |
| F       | Frequency                                   |
| Pwr     | The power                                   |
| A       | Deviation                                   |
| PGU     | Empirical genetic algorithm                 |
| 1, 2, 3 | Area numbers (1, 2, 3, and k, $k \geq 10$ ) |
| AHVDC   | Automatic high voltage direct current       |
| HPIA    | Hybrid peak area                            |
| FOIISO  | Power generation comparison                 |

|            |                                         |
|------------|-----------------------------------------|
| PI/AD/ACTS | Power transmission comparison           |
| IPFC       | Interline power flow controller         |
| SMES       | Superconducting magnetic energy storage |
| PII        | Performance index criteria              |
| AGC        | Automatic generation control            |
| DSIS       | Dish Stirling solar thermal system      |
| RDGTS      | Realistic DGTS                          |
| PVTS       | Precise wind turbine system             |
| MATLAB     | Maths laboratory                        |
| RT-Lab     | Real-time simulation laboratory         |
| TP         | Transfer function                       |
| FD         | Fractional order                        |

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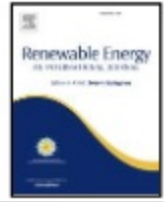
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## 1 Introduction

Power balance in PS will be violated during fault and sudden disturbances. During these conditions, AGC plays a vital role in maintaining proper power balance. AGC helps to keep PS frequency and power control within standards (Gupta 2007). However AGC starts begins with





# Employment of renewable based sources in amalgamated frequency-voltage control restructured system with TSA trained IPD(1 + I) controller

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## ARTICLE INFO

### Keywords:

Automatic frequency regulation learning  
Automatic voltage regulation  
Hydrogen aqua electrolyzer fuel cell  
IPD(1 + I) controller  
Solar photovoltaic  
Tunicate search algorithm

## ABSTRACT

The existing effort explores automatic load frequency control learning and automatic voltage regulator for manifold areas and sources under restructured situations. Sources in Area\_1 are bio-diesel and thermal; diesel and thermal plants in Area\_2. Thus, each area consists of two generating companies and two distributing companies. A unique attempt has been undergone to perform a deuce phase controller integral-proportional-derivative with one plus integral (IPD(1 + I)) controller. Various examination expresses that IPD(1 + I) is an excellent controller when compared with proportional-derivative (PD) and proportional-integral-derivative-filter (PIDN) from outlook regarding crest overshoot, grade-of-fluctuations, crest undershoot as well as the subsiding period in case of bilateral contacts. In an attempt to secure the controller's attributes bio-enthusied meta-heuristic tunicate search algorithm (TSA) is applied. Along with that, renewable source solar energy in the form of solar photovoltaic has been merged in both the operating areas. Action in existence of hydrogen aqua electrolyser – fuel cell (HAE (FC)) has also been examined using IPD(1 + I) controller for bilateral contact, in order to obtain noteworthy outcomes in a dynamic presentation. It is pragmatic that the best responses are obtained for the scheme with the inclusion of both PV and HAE (FC). Also, IPD(1 + I) parameters values at nominal condition has been analyzed to confirm its suitability for varied loading conditions without the need for optimization.

## Abbreviations and nomenclatures

|              |                                                                 |
|--------------|-----------------------------------------------------------------|
| $f$          | Equilibrium point estimate of frequency evaluated in Hertz (Hz) |
| $i$          | Amount of interconnected areas recommended                      |
| $^*$         | Finest collective recommended by exponent                       |
| $B_i$        | Share of frequency factor of interconnected areas occupied      |
| $T_g$        | Share of synchronization                                        |
| $T^g$        | Over-all instant of replication evaluated in seconds            |
| $\Delta f_i$ | Adjustment of frequency of interconnected areas recommended     |
| $H_j$        | Gradation of inertia constant                                   |
| $D_i$        | (Gradation of load alteration (p.u. MW)/Alter-                  |

ation of frequency (Hz)

|                 |                                           |
|-----------------|-------------------------------------------|
| $R_i$           | Issue linked to governor's swiftness rule |
| $\Delta P_{Di}$ | Gradation of load amendment               |
| $\beta_i$       | Credits of frequency consequence          |
| $K_i$           | Gain attribute of power system depiction  |
| $P_i^{pf}$      | Area involvement feature                  |
| $ALFC$          | Automatic load frequency control          |
| $AVR$           | Automatic voltage regulation              |
| $HAE(FC)$       | Hydrogen aqua electrolyzer fuel cell      |

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<https://doi.org/10.1016/j.renene.2023.119879>

Received 11 June 2023; Received in revised form 14 October 2023; Accepted 21 December 2023  
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## Research Article

# Frequency Control of a Realistic Dish Stirling Solar Thermal System and Accurate HVDC Models Using a Cascaded FOPI-IDDN-Based Crow Search Algorithm

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Received 12 April 2023; Revised 4 July 2023; Accepted 17 July 2023; Published 5 August 2023

Academic Editor: Yogendra Arya

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Unbalancing the real power in power system leads to fluctuation in system frequency which can cause the several negative effects on the performance and reliability of the interconnected power system. Therefore, to deal with this, the load frequency control (LFC) of a three-area asymmetric thermal power system integrated with a solar thermal power plant (STPP), a realistic dish-stirling solar thermal system (DSTS), and an accurate high voltage direct current (HVDC) link are presented in this work. For the suggested system, a novel cascade controller called fractional-order proportional-integral and integral-double-derivative with filter (FOPI-IDDN) is designed. By minimising a newly proposed performance index called the HPA-ISE and adjusting the controller and other system model parameters using a metaheuristic method called the crow search algorithm (CS). When comparing the system dynamics, it was found that the suggested FOPI-IDDN controller outperformed the FOPI, PIDN, and FOPIDN controllers. The findings of this study show that HPA-ISE shows approximately 30% and 60% improvements in settling time (ST) and peak overshoots (POS) for frequency response, and 32% and 18% improvements for the tie power responses in terms of ST and POS over ISE criteria. Also, studies on different area capacity ratios have shown that a system connected to a greater capacity ratio operates better. The realistic DSTS system with fixed and recurring insolation in area 1 and area 2 outperforms the others, according to experiments using different DSTS insolation. Also, it is discovered that the parallel AC-AHVDC link study is superior to the AC and HVDC connection research. Moreover, it seems from the sensitivity study that the CS-optimized FOPI-IDDN controller improvements obtained under normal settings are consistent across a wide range of changes.



# Evaluation of renewable and energy storage system-based interlinked power system with artificial rabbit optimized PI(FOPD) cascaded controller

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## ARTICLE INFO

### Keywords:

Automatic Generation Control  
Geothermal Power Plants  
Artificial Rabbit Optimization  
Precise Wind Turbine System  
Redox Flow Battery  
Solid Oxide Fuel Cell

## ABSTRACT

This research work addresses automatic generation control of multiple arenas and causes under various system disturbances. Sources within arena-1 comprises thermal, bio-diesel, in arena-2 sources represent thermal elements, in arena-3 sources are thermal and hydro units. An innovative endeavor has been undertaken to employ conglomerate controller with the amalgamation of proportional-integral (PI) (integer-order) in addition fractional order proportional-derivative (FOPD). Various examination manifests the fitness of PI(FOPD) overtop additional integer order controllers from perspective concerning reduced grade of crown overshoot, expanse-of-instabilities, crown undershoot in addition to subsiding period. In determination to attain the controller's features biologically enthused meta-heuristic artificial rabbit optimization is pragmatic. The minimum cost function value has been achieved as 0.000309 for the artificial rabbit optimization in comparison to various established optimization technique along with the proposed PI(FOPD) controller. It is likewise detected that occurrence of inexhaustible sources like realistic dish-Stirling thermal system in arena-1, geothermal power plant and precise wind turbine system styles the structure meaningfully improved related to origin structure when judged exclusively or all together. Accomplishment in presence of interline power flow controller besides combination of energy stowage elements alike redox flow battery in addition solid oxide fuel cell is as well inspected using PI (FOPD) controller, that offers with notable consequence in dynamic presentation in each cases separately. It has been clearly observed that in presence of all the renewables, in case of frequency deviation crown overshoot, crown undershoot, and subsiding period are 0.0053, 0.0131, and 24.32 respectively. These values are showing improvements in comparison to the individual presence of renewables in each arena. Similarly, with the presence of both SOFC and RFB for tie line power between arena-1 and arena-3, the crown overshoot, crown undershoot, and subsiding period are 0.00018, 0.0013, and 22.63 respectively. These values are showing improvements in comparison to the individual presence of Solid Oxide Fuel Cell without battery energy storage in each arena. Also, PI(FOPD) parameters values at nominal condition are appropriate for random pattern of disturbance needs no optimization, which justified the reliability of the suggested controller.

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## 1. Introduction

The concept of automatic generation control (AGC) is one of the vital matters related to control and operation of power system. An equilibrium between an expanse of power engendered and damage is the elementary necessity of power system. This equilibrium is very problematic to acquire throughout high peak stages. The disparity replicates in frequency and tie-line powers. If these differences persevere for long

period, then it leads to enormous damage [1–3]. Ghatak [4] has provided with the mathematical model of AGC. Numerous investigations are reported in the field of AGC learning. Shankar *et al.* [5] have done assessment for an autonomous system. For an interconnected system most works are undergone with thermal as causing components. Guha *et al.* [9] have judged a two-area structure with thermal as sources. Padhan *et al.* [12] and Nayak *et al.* [18] have also examined a two-arena thermal scheme. Similarly, Rajesh *et al.* [16] have analyzed a thermal interconnected five arena scheme. Arya [19] have carried analysis

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<https://doi.org/10.1016/j.asej.2023.102389>

Received 9 April 2023; Received in revised form 14 June 2023; Accepted 15 July 2023

Available online 27 July 2023

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Reference No. :- IDEAWB005674

**1. Details of Incubatee:**

|                                               |                                                                                                                                                        |                                                |                                                                                                                               |
|-----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| <b>1.1 Details of the Host Institute (HI)</b> | Haldia Institute of Technology , ICARE Complex, HIT Campus, P.O. HIT, Hatiberia, Haldia , 03224255655 , admin@hithaldia.in , 6291046166                | <b>1.2 Name of the Business Incubator (BI)</b> | Debadatta Ghosh , Associate Professor-EIE & Incharge Industry Institute Partnership Cell , iipc_hit@hithaldia.in , 7001999192 |
| <b>1.3 Category of the Incubatee</b>          | Individual                                                                                                                                             | <b>1.4 Incubatee Name</b>                      | SUMAN JANA                                                                                                                    |
| <b>1.5 State</b>                              | WEST BENGAL                                                                                                                                            | <b>1.6 District</b>                            | 24 PARAGANAS SOUTH                                                                                                            |
| <b>1.7 Email Id</b>                           | sumanjana@live.com                                                                                                                                     | <b>1.8 Mobile Number</b>                       | 8777735064                                                                                                                    |
| <b>1.9 Category</b>                           | General                                                                                                                                                | <b>1.10 Gender</b>                             | Male                                                                                                                          |
| <b>1.11 Address</b>                           | Flat No:- 152/212, Building:- NIL PRITHIBI, Road/Street:- RABINDRA NAGAR ROAD, Village/Town:- RABINDRA NAGAR, Block:- RAJPUR SONAR PUR, City:- KOLKATA |                                                |                                                                                                                               |

**2. Details of Idea:**

|                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>2.1 Title of proposed idea/innovation</b>                                                                  | Bamboo fibre reinforced biodegradable plastic bag                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>2.2 Whether the idea involves use of existing intellectual property or not, give brief detail there of</b> | No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>2.3 Briefly explain newness/uniqueness of the innovation</b>                                               | <p>Bamboo fiber reinforced plastic bag: The primary benefit of the bamboo fiber reinforced plastic bag is its biodegradability and strength. The strength of bamboo fiber-reinforced plastic is better compared with the same micron of ordinary plastic. Moreover, this product can be reused though it is significantly less thick. The method is designed to increase the biodegradability of the plastic. The bamboo powder is used in this method to increase the fragility of the bonding between plastic particles. So, this product may biodegrade faster than other plastic products. Compared to plastic of the same thickness, the bamboo reinforced bag can provide better weight carrying ability. When the bamboo powder is pressed in the gaps of the bamboo fiber cloth, then the PLA makes a strong bonding between all sides of square gaps in the cloth and makes it stronger. Besides, this bonding can be broken near bacteria or fungi, which make it easily biodegradable. Automatic production line: The production line is designed as a system that can be used for big industries and as a portable production line for small industries. The innovative design also makes it more economical than other facilities. The machine can be constructed with inbuilt thickness monitoring capability. The upper rollers help to maintain minimal resin use for the resin bath. The powder sprayer can spray necessary powder according to thickness demand. The compressor rollers also can be adjusted according to desired thickness.</p> |

|                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                   |
|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|---------------------------------------------------|
| <b>2.4 Concept &amp; Objective</b>                                                | <p>Bamboo Fiber: Bamboo is a lingo-cellulosic bast fiber. Chemical composition and properties are similar to the other bast fibers like jute and flax. When a mechanical process extracts bamboo fiber, it is not environmentally harmful, and the resulting fiber is solid and long-lasting. Bamboo fiber comes from nature and ultimately returns to nature in the end. Many scientists prove that bamboo fiber has an inherent natural antibacterial property. Biodegradable Plastic: Starch-based thermoplastics (TPS) are inexpensive and readily available. They are often blended with other materials in plastic injection molding but are commonly found in food packaging, takeout packaging for fast food, and one-time disposable utensils. Starch-based plastics are 100 percent biodegradable and can be carbon neutral. Reinforcing bamboo fiber and TPS together make a strong, waterproof and reusable plastic bag which is organic, economic and easily biodegradable. Objective: The projects primary objective is to make bamboo fiber and bamboo powder reinforcement with biodegradable plastic to make a substantial, long-lasting, waterproof, and economical carry bag for everyday use. Another objective is to construct an automatic, innovative, economic, and industrial manufacturing unit that may produce bamboo fiber and bamboo powder reinforced plastic production.</p> |                                                      |                                                   |
| <b>2.5 Specify the potential areas of application in industry/market in brief</b> | <p>The potential areas of application of this project can be divided into two part. The first part of this project delivers a unique and economic automatic manufacturing machine. The method of this bamboo fibre reinforcement is cost friendly and easy to use. The machine can be scalable to mini form to large industrial form which may generate a potential market for bamboo fiber reinforced plastic bag manufacturing industry. Another part of the project outcome is the biodegradable plastic material which is stronger than conventional plastic bags of the market. The bamboo fiber reinforced biodegradable plastic bag has a great market potential. By including sack as another product with plastic bag may increase the potential market as this project application.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                      |                                                   |
| <b>2.6 Briefly provide the market data for the potential idea/ innovation</b>     | <p>The total market potential of the manufacturing machine and bamboo fiber reinforced plastic product together is almost 28 thousand crore only for Indian market, Where market capacity of the machinery related to plastic bag manufacturing is 3 thousand crore and single use plastic bag is more than 25 thousand crore Indian rupees. The innovation and idea may compete in this huge market as a front runner. The global market is much higher than Indian market. The global market where this product may be a front runner is of almost 70 thousand crore.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                      |                                                   |
| <b>2.7 Name and details of Applicant</b>                                          | Suman Jana                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>2.8 Experience and Qualification of Applicant</b> | Ph.D. in Electrical and Electrical Engineering    |
| <b>2.9 Designation and affiliation of Applicant</b>                               | Assistant Professor, EEE Department, Regent Education and Research Foundation, Barrackpore                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>2.10 Current Development Status of innovation</b> | Idea stage                                        |
| <b>2.11 Expected time of completion of idea</b>                                   | 18 Months                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>2.12 Idea Theme</b>                               | Alternative Material for Single Use Plastic (SUP) |
| <b>2.13 Idea Sector</b>                                                           | Miscellaneous Sector (Environment, Forests, Water & Sanitation; Foods, Beverages, FMCG, Consumer Goods; Infrastructure, Construction, Housing; IT, ITES, Electronics, White Goods, Telecommunication; Metals, Engineering, Machinery, Automation and Transportation, Automotive, E Vehicles, Railways, Aviation, UAV and any other sub-sector)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                                                   |
| <b>3. Financial requirements:</b>                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                      |                                                   |

## 3.1 Activity-wise break

| Particular/Item                                                                                                                                                                                                                | Total idea project cost (Rs. In lakh) | Amount GOI assistance (Rs. In lakh) | Incubatee share (Rs. In lakh) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|-------------------------------------|-------------------------------|
| Technology related Expenditure towards machine usage charges etc., Electricity charges, Procurement of raw material , testing/Calibration charges, other charges essential for development of idea<br><b>Max (10.00) lakh.</b> | 10.000                                | 8.500                               | 1.500                         |
| Charges for mentor/handholding supporting team<br><b>Max (3.00) lakh.</b>                                                                                                                                                      | 3.000                                 | 2.550                               | 0.450                         |
| Travelling Expenses or any other item not covered as above may be allowed as per need for development of the idea<br><b>Max ( 2.00) lakh.</b>                                                                                  | 2.000                                 | 1.700                               | 0.300                         |
| <b>Total</b>                                                                                                                                                                                                                   | <b>15.000</b>                         | <b>12.750</b>                       | <b>2.250</b>                  |

## Approved Activity-wise break

| Approved By | Approved Date |
|-------------|---------------|
| PMAC        | 12/07/2023    |

| Particular/Item                                                                                                                                                                                                                | Total idea project cost (Rs. In lakh) | Amount GOI assistance (Rs. In lakh) | Incubatee share (Rs. In lakh) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|-------------------------------------|-------------------------------|
| Technology related Expenditure towards machine usage charges etc., Electricity charges, Procurement of raw material , testing/Calibration charges, other charges essential for development of idea<br><b>Max (10.00) lakh.</b> | 10.000                                | 8.500                               | 1.500                         |
| Charges for mentor/handholding supporting team<br><b>Max (3.00) lakh.</b>                                                                                                                                                      | 3.000                                 | 2.550                               | 0.450                         |
| Travelling Expenses or any other item not covered as above may be allowed as per need for development of the idea<br><b>Max ( 2.00) lakh.</b>                                                                                  | 2.000                                 | 1.700                               | 0.300                         |
| <b>Total</b>                                                                                                                                                                                                                   | <b>15.000</b>                         | <b>12.750</b>                       | <b>2.250</b>                  |

|                                             |                                                                                                         |                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Ref. No.</b>                             | INC22BWB005923                                                                                          | <b>5. Summary of the idea.</b><br>This is the section reviewers read to understand the technical solution. Please state the solution clearly. Reviewers may ask: What is the actual technical advancement or improvement provided by this solution?                                             | Bamboo fiber reinforced plastic bag: The primary benefit of the bamboo fiber reinforced plastic bag is its biodegradability and strength. The strength of bamboo fiber-reinforced plastic is better compared with the same micron of ordinary plastic. Moreover, this product can be reused though it is significantly less thick. The method is designed to increase the biodegradability of the plastic. The bamboo powder is used in this method to increase the fragility of the bonding between plastic particles. So, this product may biodegrade faster than other plastic products. Compared to plastic of the same thickness, the bamboo reinforced bag can provide better weight carrying ability. When the bamboo powder is pressed in the gaps |
| <b>6 (a) Is it a new concept?</b>           |                                                                                                         | YES                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>(b) Prior art on the concept, if any</b> | NO                                                                                                      | <b>7. Main Problem Being Addressed in the Project</b><br>(Every solution targets a certain problem. Please use this section to highlight the specific problem the solution addresses. This section can be as short or as long as needed to describe the precise problem the solution addresses) | 1. Protect nature from plastic pollution 2. Making a new industry for bamboo fiber 3. Producing organic plastic bag                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>8. Background for getting the idea?</b>  |                                                                                                         |                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>a. Who is it for?</b>                    | 1. Domestic use (Plastic bag) 2. Commercial use (Plastic bag) 3. Industrial purpose (Automated machine) | <b>b. What will it do?</b>                                                                                                                                                                                                                                                                      | 1. The organic plastic bag will replace the single use plastic bag to organic plastic bag 2. The automatic reinforcement machine will reinforcement organic plastic with the bamboo fiber in automated machine 3. The reinforcement will make bamboo fiber made bag strong and waterproof                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| c. Any unique features? Explain?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Bamboo fiber reinforced plastic bag: The primary benefit of the bamboo fiber reinforced plastic bag is its biodegradability and strength. The strength of bamboo fiber-reinforced plastic is better compared with the same micron of ordinary plastic. | 9. How simple or complex will the idea's execution or implementation be? What are the risk factors involved in executing the idea?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | There should not be any risk involved during the execution of the project.                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 10. How soon could the idea be put into operation? (TRL of prototype)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 12 Months                                                                                                                                                                                                                                              | 11. How much investment would you need for prototyping of the Idea?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 6 Lakhs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 12. (a) How do you intend to protect your idea (i.e. your intellectual property or IP)? Status of IPR (If any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Atleast 1 Patent.                                                                                                                                                                                                                                      | (b) Related Background<br>This section is used to highlight information that can be used by the reviewers or patent attorney to help put the solution in proper context. You can think of this section as something similar to the introduction section of an academic publication. This section is specifically reserved for other people's work (please include competitive work) as well as your past work that you believe will aid the reviewers in understanding the technical landscape. Data related to or supporting your solution should NOT be in this section, it should be in Section III: "How is this Solution Made and Used." | Introduction: Mother Nature is suffocating due to pollution created by human beings. Environmental pollution is increasing gradually and causing a severe impact on living organisms, including humans. Non-biodegradable plastics are one of the primary causes of both soil and water pollution. Around the world, one million plastic bottles are purchased every minute, while up to five trillion plastic bags are used worldwide yearly. Half of all plastic produced is designed for single-use purposes |
| 13. How is This Project Made and Used: Please describe in as much detail as possible how the innovation is implemented. This includes details on how you actually make, assemble, synthesize, or build the solution and details on how the solution is used once it is made. Reviewers will ask: How does the technical innovation actually work – or – what is the detailed process to achieve the technical innovation? Please help convince the reviewers with supporting statements using as much of the following that is available: your thoughts, logic, supporting literature, and/or experiments. | The proposal is still in idea stage and do not have any prototype implemented.                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Upload Block diagram/ flow chart/ Circuit Diagram/Pictures                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | View/Download                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Uploaded Minutes of the Selection Committee                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | View/Download                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

## Application Remarks

| Action | Date                       | Status              | Remark                                                                                                                                                                                                      |
|--------|----------------------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PMAC   | 12/Jul/2023<br>05:18:33 PM | Approved By<br>PMAC | The financial sanction is as approved by the committee in the 4th PMAC meeting.<br>Check your mail and do the needful as instructed on priority basis. This may be treated as most urgent.<br>View/Download |

☒ I declare that:

1. I have read the entire scheme guidelines and shall abide by all the requirements stipulated therein for seeking financial assistance.
2. I hereby declare that information given above is true to the best of my Knowledge and that I have not withheld/distorted any material fact.
3. Any information/ documents that may be required to be verified shall be provided immediately before the concerned authority.
4. I hereby declare that I have not availed any financial assistance for this purpose from any other scheme from any Central/ State govt. agency.
5. In case the Idea is approved, Host Institute would undertake to make facilities available to carry out the development arrange for the submission of periodic progress reports and other information that may be required by the Ministry.
6. I certify that the accounts of the funds received and spent will be kept and made available on demand, as per scheme guidelines
7. I certify that the funds will be used only for Idea development as per activities defined in Scheme Guidelines & no funds out of this grant will be utilized for any other activity/production purposes.