INTELLIGENT TECHNOLOGIES FOR SCIENTIFIC RESEARCH AND ENGINEERING

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Intelligent Technologies for Scientific Research and Engineering

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FOREWORD

The fusion of our human and science-based infrastructure will be remembered in the twenty-first century. As represented in the Internet and "e-commerce," the injection of information technology into our economy is altering communication, reducing the globe, producing riches, and transforming everyday routines. Such remarkable research-based skills contrast with a sobering reality: Scientific discoveries, new innovations, and technology have piqued the curiosity of American adults for more than two decades, according to studies. However, just around one out of every researcher understands or appreciates the importance and process of scientific investigation. While the public has a high level of faith in science, for many it is a blind trust. The invention and effect of various major technologies, some of which are detailed here. The advancement of science and technology requires more from every one of us. One danger is that technical virtuosity separates what most people can see and manage from what a few people who have been specifically equipped and taught can see and manipulate. Even if we are motivated to comprehend the consequences of new information, we need more straightforward discussion of dangers and advantages, as well as clearer explanations of why the most recent discovery is significant. Citizens want facts that will educate their thinking before they adopt another new miracle designed to alleviate, cure, or otherwise enhance life. We can easily go throughout the world and provide products and services wherever they are required. Expanding computer and communications technologies are allowing access to massive amounts of information and entertainment. As impressive as these technical accomplishments are, there are undoubtedly many more significant obstacles and possibilities to be achieved. While some seem to be distinct, many others are indistinct, and many more are undoubtedly beyond the scope of most people's minds. Science and technological advancement seems to be so unstoppable that the importance of policy decisions is frequently overlooked. Although knowledge seems to develop in a natural manner, sponsorship and, increasingly, stewardship have played an important role in the twentieth century.

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PREFACE

The book aims to bring together leading academics, scholars and researchers to exchange and share their perspectives and study findings on all facets of technology, engineering, and innovation. As it applies to engineering processes and research, this book concentrates on smart technology. The following subjects are discussed in the book: networking, signal processing, artificial intelligence, control and machine engineering, clever electronic circuits and devices, connectivity, computer, electrical, photonics, mobile computing, big data, Internet of Things, power electronics, cyber-attacks, nanotechnology, MEMS, crystals, metal physical properties, solids, liquids, and crystals. People have started to pay heed to the pursuit of smart and refined lives, contributing to the advancement of smart technologies in different industries.

On behalf of the editors, we would like to thank everyone who took part. First and foremost to the authors, whose excellent work is at the core of the book, and we gratefully congratulate all those involved and wish them great success. We want to thank our family and friends for their support and encouragement while we worked on this book. We offer all credit and respect to our almighty Lord for his bountiful grace, which enabled me to finish this book successfully. We would also like to thank Bentham Science Publisher and its whole team for facilitating the work and providing the opportunity.

The content of this book is summarized as follows

1. In Chapter 1, The receiving antenna is critical in an RF energy harvesting system because it collects energy from nearby radiating sources. The amount of harvestable energy is influenced by antenna characteristics such as gain, radiation pattern, and impedance bandwidth, therefore, choosing the correct receiving antenna is crucial. The microstrip patch antenna is a popular choice because of its low profile, low cost, and ease of manufacture.

2. In Chapter 2, Routers are often used to connect networks to the internet. Wi-Fi allows anybody with a computing device to connect to the internet at fast speeds without the need for a cable connection. Wireless networks use the Open System Interconnect (OSI) standard model for data transport. Wireless networks employ this reference model in the same manner as wired networks do, with a few differences in the data connection layer, since wireless networks coordinate data access to a shared air medium and deal with failures due to the wireless medium's inherent nature.

3. In Chapter 3, Temperature dependent Quantum Cascade Lasers are known for their advantages when compared to conventional lasers. In this work, we will focus on their temperature dependent capabilities. This research work reports the impact of device parameters on the transient and steady state dynamics of the device. Also, an analysis of the analog modulation characteristics on the device is carried out in detail.

4. In Chapter 4, The fundamental research work's critical aim has been to investigate an advanced study on temperature-affected electro-optic characteristics of $In_{0.73}Al_{0.07}Ga_{0.20}As/In$ Pheterointerface nanostructure in fiber-optic communication systems underpolarizing transverse bi-modes. In this advanced computing, under the various effects of temperatures, the various energy values of C-V(Conduction-Valence) quasi-Fermi sublevels with the various values of carriers of charge (in cm^{-3}) have been illustrated curvedly.

5. In Chapter 5, The *in-silico* study on protein-peptide docking involves initiating the

biomolecular interaction to identify compatible peptides with antibacterial properties. The current research elucidates a computational module for the discovery. The protein-peptide docking of marine peptides against the marine bacteria and the gills of teleost fish in CABS-DOCK resulted in a compatible docked structure with the highest accuracy.

6. In Chapter 6, Composting allows for long-term management of organic wastes, turning it into nutrient-rich bio-manure while also reducing other environmental impacts. Traditional methods of monitoring and process management present a number of challenges in terms of efficiently using available resources to produce high-quality compost. As a result, smart composting technologies must be introduced to make it feasible for small-scale units in urban areas as well as large-scale operations in outlying areas.

7. In Chapter 7, An equivalent mathematical model of a Brushless DC motor is developed to obtain various parameters required for more accurate control of the drive. The analysis of the modelled drive is performed through simulation results at various speed steps much more suitable for adjustable speed drive. The drive suggested with a PID controller, equivalent mathematical model and Back emf detection provide a quick and efficient steady state performance during speed changes.

8. In Chapter 8, Some physico-chemical properties of hyperbranchedpoly([1,2,3]-triazol--[1,3,5]-triazine)s synthesized by thermal azide-alkyne cycloaddition of AB2 and A2B monomers were studied by DSC, TGA, SEC and other methods. Density, thermal stability, shock, and friction sensitivity were determined.

9. In Chapter 9, The high electrical conductivity of carbon nanotubes(CNTs) has motivated their incorporation into polymers for several purposes, including electrical conductivity enhancement and sensing. Some studies have suggested that thin films of CNT/polymer composites can be used for humidity sensing. This study focuses on the influence of humidity on the electrical conductivity of CNT modified proxy composite.

10. In Chapter 10, The Power Factor Correction (PFC) Bridgeless (BL) Boost converter fed BLDC motor drive as a cost-effective solution for low power applications. A BL configuration of the boost converter is proposed, which eliminates the diode bridge rectifier, thus reducing the conduction losses associated with it. A PFC BL boost converter is designed to operate in Discontinuous Conduction Mode (DICM) to provide an inherent PFC at mains by using ANFIS-PID controller.

11. In Chapter 11, The Wireless Power transfer technique in electric vehicle charging using the Dual Active Bridge (DAB) system. The source end of the primary coil is connected with a constant high-frequency DC-DC converter with capacitive compensation, and the secondary coil is connected with capacitive compensation in moving electric vehicles (EVs). A transformer is used to improve the input power, and a compensating capacitor is used to reduce the amount of current leakage.

12. In Chapter 12, Vibrations play a very important role in the rotor systems. In the manufacturing of the rotor system, the imbalance caused by the offset impeller, and eccentricity produces unwanted vibrations. Various studies were carried out on unbalanced factors of rotor systems like eccentricity, crack, etc. But the effect of impeller offset due to manufacturing fault is not paid much attention.

13. In Chapter 13, The interfacial sliding motion of carbon nanotubes (CNTs) within a polymeric hosting matrix gives rise to energy dissipation. By tuning the interfacial shear strength (ISS) of the CNT-matrix interface, the dissipation can take place within tunable

ranges of strain amplitudes. This is the basis for conceiving new multilayered carbon nanotube nanocomposites in which different layers with tunable ISS can lead to a concurrent optimization of strength and dissipation, often seen as two conflicting targets. Such optimization is tackled by a novel meso-mechanical nonlinear inelastic model proven to predict the damping capacity of CNT nanocomposites effectively.

14. In Chapter 14, The composite materials find various applications like turbine blades, helicopter blades, airplane wings, medical instruments, sports equipment, etc. They are subjected to a variety of dynamic excitations. The resonance condition is desirable for applications like vibration actuators, and musical instruments. And due to resonance, catastrophic failure may occur for most of the applications. Therefore, a study of dynamic behavior plays an important role in designing materials either to avoid or enforce resonance conditions.

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CHAPTER 1

Antenna Technologies for Wireless Communication Systems

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Abstract: The receiving antenna is critical in an RF energy harvesting system because it collects energy from nearby radiating sources. The amount of harvestable energy is influenced by antenna characteristics such as gain, radiation pattern, and impedance bandwidth; therefore, choosing the correct receiving antenna is crucial. The microstrip patch antenna is a popular choice because of its low profile, low cost, and ease of manufacture. Many publications on microstrip patch antennas have been written over the years for various applications, such as mobile communications, radio frequency identification (RFID) and medical telemetry. We provide a folded shorted patch antenna for indoor mobile communication systems in this research. In recent years, there has been a lot of new work in the field of microstrip antennas, and it is one of the most active sectors in business communications. Mobile communications, wireless interconnects, wireless local area networks (WLANs), and cellular phone technologies are among the most rapidly increasing industrial areas today. A microstrip antenna is a popular option due to its light-weight, compact volume, low production cost, and ability to operate at dual and triple frequencies. Microstrip antennas, on the other hand, suffer from a number of disadvantages. A fundamental disadvantage of microstrip patch antennas is their small bandwidth.

Keywords: WSN, Applications, RFID, WLAN.

INTRODUCTION

In recent years, there has been a spike in interest in the implementation of wireless sensor networks (WSN). Structure monitoring, habitat monitoring, and healthcare are just a few of the uses for these network systems, which are made up of geographically spread sensor nodes. One emerging WSN application is precision

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agriculture, in which sensor nodes are deployed in the field to monitor soil factors like moisture, mineral content and temperature. The information acquired by these sensors might be used to improve irrigation management, agricultural production forecasting and crop quality. Energy supply has been a key limiting factor in the lifetime of agricultural WSNs, since their sensors are often supplied by onboard batteries with limited energy ratings and lifespan. As a consequence, these batteries must be replaced right away. Labor and maintenance expenses may be expensive if the networks are deployed in difficult-to-service locations.

Before the worn-out batteries in a wireless soil sensor buried underground, for example, can be replaced, they must be unearthed. Furthermore, most wireless sensor batteries contain heavy metals that, if disposed of improperly, might harm the environment. Energy harvesting [1 - 5] is a possible alternative to batteries in which ambient energy is gathered, converted to electrical energy, and stored to wireless power sensors. In the literature, many energy harvesting systems have been reported, employing diverse energy sources, such as light, temperature difference, electromagnetic field, human power, and mechanical vibration. The operating environment and the wireless sensor's energy requirement are the most important factors to consider when selecting an energy harvesting system for a certain application. The main goal of this study is to create a wireless soil sensor network that can be utilized for detection and monitoring. In this network system, a number of wireless sensor nodes are positioned around the exterior of a property, as depicted. These nodes are usually static and may be found in the open, behind trees, or even buried in dry leaves or soil. The soil sensor uses roughly 29.4 J of energy throughout the course of 18 hours of operation. RF energy harvesting, in contrast to other energy collection methods, can not only be used to replenish the energy required to power the sensors, but it can also provide a more regulated and predictable power supply. This approach collects the RF energy released by a controlled transmitter using a receiving antenna linked to each wireless sensor node. The input energy is converted into a DC voltage using a power conversion circuit. The DC energy is stored in an energy storage device before being used to power the sensors [6 - 10].

In today's technology, flexible broadband antennas are in high demand, which is pushing up the need for broadband band antennas. However, when technology advances and new features of devices are introduced, the Broadband band Antenna need to be modified again. In recent years, rapid advances in communication technology have forced the development of antennas that are lightweight, low profile, high performance, and multi-band capable. Microstrip patch antennas may meet these requirements. Wideband and multi-band antennas are advised to avoid having to utilize several antennas for different operating frequencies. However, designing an antenna that can simultaneously cover

Bluetooth, Wi-MAX, and WLAN frequencies, is a challenging task. Several distinct multi-band antenna designs have lately been proposed. To achieve multi-band operation, different planar monopole antennas employ complementary split-ring resonators, branch strip and hook-shape strips, branch strips and rectangular slit in the ground plane], circular arc-shaped strips and straight strips, and U-shaped strips. Planar inverted-F antennas (PIFAs) also give multi-band performance by altering the radiating components by adding slots that provide distinct resonance paths and hence several frequency bands. The coplanar inverted-F antenna's open arms and ground slots allow multi-band performance. There is also a tiny inverted-F antenna described, although it has a lot of cross-polarization. As a consequence, research into employing Micro-strip Antennas to achieve Broadband band Antenna operations is in great demand. Almost all work in the Broadband Antenna band has been surveyed [11 - 15].

WIRELESS ANTENNA

Antennas with a variety of frequencies and a lower footprint are required due to the rapid growth of technology in the field of contemporary wireless communication systems. In the current environment, several antenna frequency must be designed to fulfill the demands of diverse applications. This is done using a microstrip patch antenna, which has a number of advantages, including small size, low weight, low cost, low profile, simple manufacture, and easy feed network addition. Microstrip antennas provide a larger range of physical features than typical microwave antennas. One of the antenna's key functions is to convert electrical impulses to electromagnetic waves and *vice versa*. The feed of an antenna is quite important. Coaxial probe feeding, microstrip line, aperture coupling, and proximity coupling are all common feeding techniques in Microstrip antennas. The coaxial feeding approach was used in our case. It has two conductors, with the inner conductor linked to the patch and the outside conductor attached to the ground plane.

Coaxial feeding offers the benefits of being easy to build, match, and have minimal counterfeit radiation, but it has the drawbacks of having a restricted bandwidth and being difficult to copy, especially for thick substrates. Traditional microstrip antennas' major disadvantage is their restricted bandwidth; nevertheless, large bandwidth is necessary in today's wireless communication environment, therefore bandwidth increase is crucial. The drawback of microstrip antennas may be overcome by adding multiple slots to the patch. It also has the benefit of shrinking the size of the product. The addition of slots to a microstrip patch antenna provides the following advantages: enhanced bandwidth, efficiency, VSWR improvement, lower size, and gain. It also creates several output beams, making it suitable for applications like reconfigurable antennas that

CHAPTER 2

Software Defined Networking Concepts, Applications and Wireless Communication

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Abstract: This chapter has covered the most popular protocols, including those for Bluetooth, Wi-Fi, WiMAX, and cellular networks. There is a rundown of what is needed to set up a basic wireless network. The literature seeks to describe the most extensively used wireless protocols and technologies. After that, an overview is presented of the advantages of wireless networks over wired systems. In addition, the chapter highlights some of the most serious security vulnerabilities that wireless networks face. There are a variety of approaches that may be employed to reduce these risks and safeguard the network's privacy and security. A thorough examination of the potential applications of wireless networks in education and training is also provided, along with proof that the improvements and affordability of wireless technology have helped the education sector.

Keywords: Network, AI, Data mining and Applications, IoT.

INTRODUCTION

The introduction of the computer and subsequent development of communication networks may be regarded as the most significant accomplishment of the twenty-first century. This breakthrough has changed the way individuals interact and process information. The network capabilities of computer systems have been used by the government, corporations, and people, and they have all enjoyed considerable advantages. The two most popular types of networks are fixed connections (which employ wires) and wireless networks (which use waves to transmit data). The massive communication network's backbone is fixed connections, which mostly employ fibre optics and Ethernet. Wireless networks, on the other hand, have become more popular in recent years. Wireless networks were limited due to the high cost of wireless equipment, such as integrated routers

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and access points, as well as laptops. Hardware costs have plummeted, making wireless networks affordable to a broad spectrum of consumers and enterprises. Furthermore, technological improvements have enhanced wireless networks' capacity and efficiency, enabling them to compete effectively with wired networks. This article will focus on wireless networking, covering the many types of wireless technologies that are often used as well as the security approaches used to protect wireless technology [1 - 5].

A discussion of how wireless technology may be used in educational and training situations will also be discussed. Wireless networking is the use of cross-vendor industry standards, such as IEEE 802.11, to enable nodes to communicate without the usage of cables. In the infrastructure of wireless networks, standard protocols are employed, which are oriented according to the network's demands. Consequently, depending on the devices, the quality and capacity of a wireless network differ.. Wireless networks are often needed to accommodate a wide range of manufacturers' products. As a consequence, networks must be able to cope with a wide range of hardware technologies, topologies, and transport protocols, as well as control traffic flow inside the network. All wireless networks make use of electromagnetic spectrum waves. Wireless local-area networks (Wireless LANs), for example, use high-frequency electromagnetic waves to transfer data. The transmitter and receiver modulate and demodulate the radio waves used to transfer data accordingly. They employ the industrial, scientific, and medical (ISM) radio bands as well as the unlicensed-national information infrastructure (U-NII) frequencies [6 - 10].

Routers are often used to connect networks to the internet. Wi-Fi allows anybody with a computing device to connect to the internet at fast speeds without the need for a cable connection. Wireless networks use the Open System Interconnect (OSI) standard model for data transport. Wireless networks employ this reference model in the same manner as wired networks do, with a few differences in the data connection layer, since wireless networks coordinate data access to a shared air medium and also deal with failures that happen due to the wireless medium's inherent nature. Radio waves are used to transport data at the physical layer. A site study is needed before building a wireless network. When building a small wireless network, this step may be skipped, but it is essential when establishing a big wireless network. This is because wireless networks use the same frequency band as other devices such as garage door openers and microwave ovens, and avoiding interference from these devices is vital if the wireless network is to achieve its goal of reliable communication. The most expensive part of setting up a wireless network is the physical site placement, and this deployment is an evolutionary process since the network may need to modify to serve an expanding number of users and meet demand for more capacity and improved service

quality. Large networks should be constructed with manageability and reliability in mind since they may grow to the point where the network administrator is unable to adequately manage them [11 - 15].

You will need a range of hardware and software components to set up a wireless network. An access point is a piece of hardware that links a wireless network to a wired LAN. According to Wi-Fi, the access point is the device that transmits and receives the signals used to communicate among the network's computer devices. Wireless access points are available in a number of sizes, with the size you choose based on the network speed you want. The ability of computer systems to network has been utilised by the government, corporations, and individuals, who have all reaped significant benefits.

WIRELESS NETWORKING

There are several factors to consider when choosing gear for a wireless network. Equipment interoperability is necessary if the network intends to support all accessible protocols (such as 802.11a/b/g). The network's expected range is also an important issue to consider. Specifications like transmission power and antenna gain should be used to determine the device's range. Almost all wireless networks are connected to the internet.

A router, which is a device that enables a single internet connection to be shared by several computer devices on the same network, is helpful in this situation. Personal networking devices that can connect to wireless networks include laptops, personal digital assistants, tablet PCs, and pocket PCs. All devices connected to the network must run on an operating system that supports wireless connectivity. Wireless access points and the client devices connected to them must be properly set up in order to operate a TCP/IP network. A DHCP server gives wireless clients on network setup information including IP addresses, default gateways, and subnet masks. If the administrator wishes to severely restrict the users, the IP addresses may be manually imputed. Such a modification would obviously be labour intensive and unworkable for a wireless network with a big number of users.

Mobile Ad hoc Networks (MANETs) are prone to a number of threats. Ad hoc networks are difficult to secure because of their inherent features, such as their high dynamism, limited bandwidth, and restricted resources in end devices. A centralised security solution is not possible with such variable connectivity and limited resources, but a distributed security solution is. The article explains a distributed architecture security paradigm in which the network is divided into clusters, each with its own cluster head node. This cluster head node also functions as a router, allowing proactive hidden routing for inter-cluster security

CHAPTER 3

Impact of Device Parameters on the Modulation Characteristics of Temperature Dependent Quantum Cascade Lasers

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Abstract: This study examines the effect of device parameters on the transient and steady-state dynamics. In addition, the device's analogue modulation properties are thoroughly examined. Under various cold finger temperature circumstances, the parameters terminal voltage (V), spontaneous emission factor (SEF), number of stages (M), and mirror reflectivity (R) are modified to see how they affect device properties. To analyze modulation properties, such as bandwidth, maximum modulation depth and corresponding frequency, the device is operated by the haversine input current. According to the findings, the lasing activity is delayed when the cold finger temperature rises, thereby increasing the threshold current regardless of device parameter modification. When T=45K and 0.65A current are used, a maximum Modulation Depth (MD) of 18% is produced. The greatest bandwidth of 27GHz is obtained when the injected current is 1.05A at T=15K. The minimal frequency required to obtain maximal MD rises as current and cold finger temperatures rise.

Keywords: Bandwidth, Cold Finger Temperature, Modulation Depth (MD), Quantum Cascade Lasers (QCLs), Terminal Voltage.

1. INTRODUCTION

Quantum Cascade Lasers (QCLs) are compact but powerful sources with their mid-infrared wavelength operations. At a higher temperature, the escape of electrons impacts the optical injection efficiency, threshold current and output power of a QCL [1, 2]. Other parameters that affect the operation of a mid-infrared laser include the non-radiative scattering times and the

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electroluminescence spectrum. In fact, these parameters limit the operating temperature range of the device. Experimenta results suggest room temperature operation of a mid-infrared QCL [3]. Also, in the absence of a magnetic field, the device can provide stable operation up to 200K [4]. A detailed investigation of the impact of device parameters in a 9μm QCL, and short optical pulse generation by gain switching are presented in a study [5, 6]. The application of QCL in free-space optical communication is explored in detail [7 - 10]. The intrinsic impedance characteristics of QCL are well reported [11]. Other related works pertaining to this study are available as a reference [12 - 14]. The model reported in a study [15] accounts for the temperature and voltage dependence of all parameters in the reduced rate equation. The device considered in the study has a threshold current of 0.44A, 0.49A and 0.54A at cold finger temperatures of 15K, 35K and 45K respectively [15]. The effect of the device parameters on the steady state and transient characteristics and the analog modulation characteristics of the device have not been explored to date. Hence, a detailed analysis is carried out to ascertain the applications of the device in Radio-over-Fiber (RoF) areas. The reduced rate equations are numerically solved using an ODE solver in the MATLAB to study the effect of device parameters on device characteristics.

This research work is organized as follows. Section II explains the characteristics of temperature-dependent QCLs analyzed using the reduced rate equation model. Section III accounts for the analysis of the effect of various device parameters on the device characteristics. Section IV explores the analog modulation characteristics of the device. Section V summarizes the findings.

2. CHARACTERISTICS OF TEMPERATURE DEPENDENT QCLS

Temperature-dependent QCLs operating at 2.59THz up to 50K are made of GaAs/AlGaAs. The reduced rate equations of QCL are given below [15]:

$$\frac{dS(t)}{dt} = \frac{-S(t)}{\tau_p} + \frac{\beta_{sp}}{\tau_{sp}(T,V)} N_3(t) + MG(T,V) \frac{\left(N_3(t) - N_2(t)\right)}{1 + \epsilon S(t)} S(t) \tag{1}$$

$$\frac{dN_3(t)}{dt} = -G(T,V) \frac{\left(N_3(t) - N_2(t)\right)}{1 + \epsilon S(t)} S(t) - \frac{1}{\tau_3(T,V)} N_3(t) + \frac{\eta_3(T,V)}{q} I(t) \tag{2}$$

$$\frac{dN_2(t)}{dt} = G(T,V) \frac{\left(N_3(t) - N_2(t)\right)}{1 + \epsilon S(t)} S(t) + \frac{1}{\tau_{32}(T,V)} N_3(t) + \frac{\eta_2(T,V)}{q} I(t) - \frac{1}{\tau_{21}(T,V)} N_2(t) \tag{3}$$

$$\frac{dT(t)}{dt} = \frac{1}{mc_p}\left(I(t)V\big(T(t), I(t)\big) - \frac{(T(t) - T_0)}{R_{th}}\right) \quad \textbf{(4)}$$

where I(t) is the injected current, S(t) is the photon number, $N_3(t)$ and $N_2(t)$ are the carrier numbers in upper and lower lasing levels respectively. Eq. (4) models the temperature of the active region of the device. Many parameters in the rate equations depend on temperature (T) and voltage (V) that are expressed as functions of V and T, (V, T) [15]. The rate equations are solved numerically to determine the steady-state characteristics of the device under voltage-dependent case (V=2.80V). The results are depicted in Fig. (**1**), where the device has a threshold current of 0.4A, 0.44A and 0.49A at cold finger temperatures of 15K, 35K and 45K respectively. The results of steady-state characteristics agree well with Agnew *et al.* [15] and validate our simulation approach. In the next section, the impact of the device parameters namely terminal voltage (V), spontaneous emission factor (β), number of stages (M) and mirror reflectivity (R) under different cold finger temperature conditions on the device characteristics is evaluated.

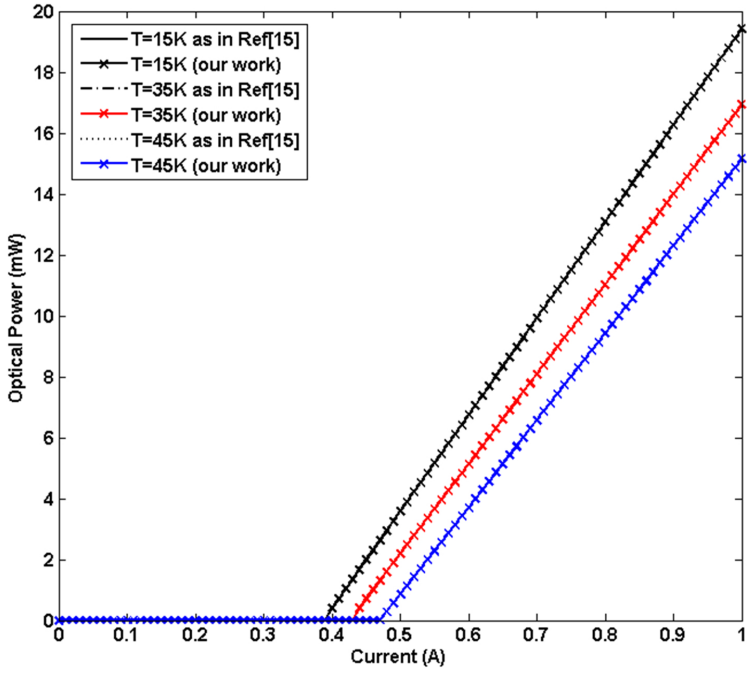

Fig. (1). Voltage dependent Steady State (P-I) characteristics of QCL (V=2.80V).

CHAPTER 4

An Advanced Study on Temperature Affected Electro-optic Properties of $In_{0.73}Al_{0.07}Ga_{0.20}As/InP$ in Fiber-optic Communications under Bi-modes

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Abstract: This fundamental research work has aimed to investigate an advanced study on temperature-affected electro-optic characteristics of $In_{0.73}Al_{0.07}Ga_{0.20}As/$. In Pheterointerface nanostructure in fiber-optic communication systems underpolarizing transverse bi-modes. In this advanced computing, under the various effects of temperatures, the various energies values of C-V(Conduction-Valence),quasi-Fermi sublevels with the various values of carriers of charge (in cm^{-3}) have been illustrated curvedly. Next, the temperature-dependent computing performances of NI(Near Infrared) material gains within the photon's wavelength and concentration values of carriers under polarizing transverse bi-modes have been investigated graphically in this chapter. In addition, temperature-influenced performances of ROFs (Relaxation Oscillation Frequencies) in Hz with various current values in Acm^{-2} have been computed graphically. Further, the graphical performances of peak RIC (Refractive Index Change) with various temperature values for both polarize TE & TM-modes. In the computational investigation through the results, the crest values of NI-material gain amplification have been found corresponding to two peaks at the photon's wavelengths ~ 1331 nm and 1551 nm for various effects of temperatures under TE-mode. Although, under TM-mode, the crest value of NI-material gain amplification has been found,corresponding to a single peak at the wavelength ~ 1331 nm for various effects of temperatures. The NI-emitting light of peak intensity emitted by the proposed nanoscale-heterogeneous junction-based nanostructure of wavelengths ~ 1331 nm and 1551 nm has been largely utilized in the FCs (Fiber-optic Cables) based NI-telecommunications and several NI-therapies by TIM (Total Internal-reflection Method) with minimal attenuation loss of appropriate NI-signals (in dB km^{-1}) on account of no dispersions, no scattering and no absorptions in the emerging and advanced nanotechnology, medical nanosciences and nanoscale-biotechnology.

Keywords: C-V quasi Fermi sublevels, FICs, FRs, $In_{0.73}Al_{0.07}Ga_{0.20}As$, InP, NI-communication, NI-material gain amplification, NI-therapies, NI-signal loss, RIC, TIM.

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INTRODUCTION

A big variation has been observed in the homo-junction type and hetero-junction type based nano-scaled structures due to their different band structures and other various emitting light characteristics. The nano-scaled hetero-structures [1 - 10] are generally defined as the proper combinations of poly-hetero-junctions. Owing to emitting various types of E-M radiations in today's world, the nano-scaled hetero-structures have cardinal contributions. Owing to better signal quality, in today's world, fiber optic cables based NI-telecommunication and several NI therapies have a paramount role. In this book chapter, in advanced computing, under the various effects of temperatures, the various energy values of C-V (Conduction-Valence) quasi-Fermi sublevels with the various values of carriers of charge (in cm^{-3}) have been illustrated in curves. Next, the temperature-dependent computing performances of NI (Near Infrared) material gains with the photon's wavelength and concentration values of carriers under polarizing transverse bi-modes have been investigated graphically. In addition, temperature-influenced performances of FRs (Frequencies of Relaxation-oscillations) in Hz with various current values in Acm^{-2} have been computed graphically. Further, the graphical performances of peak RIC (Refractive Index Change) with various temperature values were identified for both polarized TE & TM-modes. In the computational investigation of the results, the crest values of NI-material gain amplification have been found corresponding to two peaks at the photon's wavelengths ~ 1331 nm and 1551 nm for various effects of temperatures under TE-mode. Although, under TM-mode, the crest value of NI-material gain amplification has been found corresponding to a single peak at the wavelength ~ 1331 nm for various effects of temperatures. The NI-light of peak intensity emitted by the proposed heterogeneous junction-based nanostructure of wavelengths ~ 1331 nm and 1551 nm has been mostly utilized in the fiber-optic based NI-communications and NI-therapies through the process of TRs (Total-internal Reflections) with minimal attenuation loss of NI-signals in dB/km on account of zero dispersions, scattering and absorptions in the emerging nanotechnological and medical fields.

SIMULATED NANOSTRUCTURE AND THEORETICAL PARAMETERS

The appropriate compositions and proper parameters of the proposed $In_{0.73}Al_{0.07}Ga_{0.20}As/InP$ type hetero-nanostructure have been shown in Table **1**. Further, (Fig. **1**) shows the computational schematic diagram of $In_{0.73}Al_{0.07}Ga_{0.20}As/InP$ hetero type nanoscalestructure.

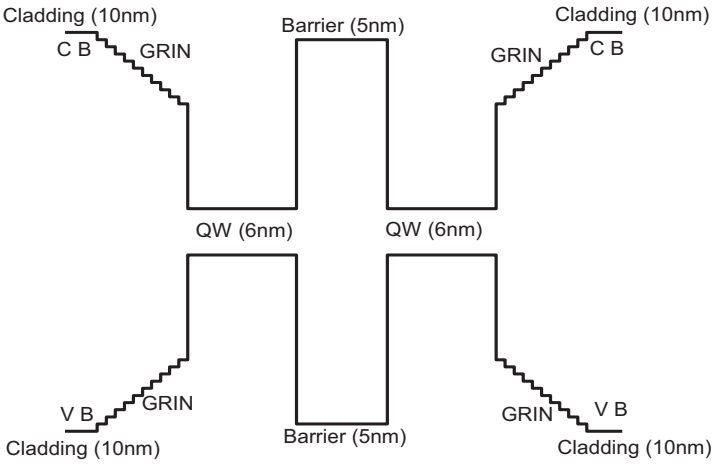

Fig.(1). The schematic diagram of $In_{0.73}Al_{0.07}Ga_{0.20}As/InP$ heterointerface nanostructure.

Table 1. The parameters of simulatively proposed $In_{0.73}Al_{0.07}Ga_{0.20}As/InP$ heterogeneous-nanostructure

Specified Net Five RNLs	Values of Compositions x and y For Specified RNLs ($In_{1-x-y}Al_yGa_xAs$)	Values of Thickness of Specified RNLs in (nm)	Values of Photon's Wavelength in (nm)	Values of Energies of BOs in (eV)
RNCL (C.B.)	0.00, 0.48	10	083711	0.23541
RNBL (C.B.)	0.34, 0.25	05	103521	0.16232
QNL	0.21, 0.08	06	155430	0.06141, - 0.06141
RNBL (V.B.)	0.34, 0.25	05	103521	- 0.16232
RNCL (V.B.)	0.00, 0.48	10	083711	-0.23541

The intensity of NI-optical-gain [11 - 20] of nanostructure has been defined by relative intensity per unit length. The temperatures and quasi-Fermi energies dependent mathematical relation of the intensity of NI-gain [15] has been defined by the following appropriate equation (1).

$$G(\hbar\omega) = \frac{q^2\hbar 2\pi}{2n_{eff}(\hbar\omega)m_0^2\varepsilon_0 c} \times \left[1 - \exp\left(\frac{\hbar\omega - \Delta f}{k_b T}\right)\right] \times \sum_{nc,nv} \frac{|M_b|^2 f_c f_v}{4\pi^2 L_W} \times \frac{(\hbar\pi\tau)dk_x dk_y}{\pi(\{\hbar\omega_{nc} + \hbar\omega_{nv} + \hbar\omega_{sg}\} - \hbar\omega)^2 + (\hbar\pi\tau)^2} \quad \textbf{(1)}$$

CHAPTER 5

Protein-Peptide Docking: An Initiation to Discover Therapeutic Peptides

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Abstract: The *in-silico* study on protein-peptide docking involves initiating the biomolecular interaction to identify compatible peptides with antibacterial properties. The current research elucidates a computational module for the discovery. The protein-peptide docking of marine peptides against the marine bacteria and the gills of teleost fish in CABS-DOCK resulted in a compatible docked structure with the highest accuracy. Protein-peptide docking resulted in maximum compatibility for "ELLVDLL" derived from marine bacteria than "FIHHIIGGLFSVGKHIHGLIHGH" derived from the tapaila gills of *teleost* fish concerning receptors of resistant bacterial strains.

Keywords: Global docking, PDB, Peptides, Protein-peptide docking, Therapeutics.

INTRODUCTION

In the current decade of biologics, peptides serve as promising candidates for the development of drugs [1 - 3]. Initiating a rational design process to identify a therapeutic peptide requires the structural characterization of biomolecular interactions. At present, multiple computational approaches identify biomolecular interactions from 'Protein-Peptide docking' [4 - 7]. The results of protein-peptide docking techniques are the initiatives to identify the lead molecules for potential therapeutic applications [8 - 10].

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METHODS

Bioinformatics is vital to improve the significance in predicting position-specific binding associated with the function of biomolecules based on binding and stimulation [11]. Protein-peptide docking has been a trending field for developing therapeutics at a lower cost than other methods for designing drugs [12]. **Cabs Dock** provides a layout for identifying the biomolecular interactions between a protein and a peptide based on flexible docking [13 - 15]. In CABS DOCK, we obtained models with high accuracy (over 80%) for bound and unbound dataset cases (sufficient for practical applications) [14].

RESULTS

The peptides of marine's bacteria (Peptide Sequences ELLVDLL) and tilapia gills of teleost fish (Peptide sequences: FIHHIIGGLFSVGKHIHGLIHGH) along with PDB structure 3QKY (organism: *Rodothermus marinus*-Strain: ATCC 43812/DSM 4252/R-10) and 1M0G (organism - *Notothenia neglecta*) in CABS DOCK (Figs. **1-6**); the model with maximum probability based on contact map exhibits the *in-silico* mimic of antibacterial activity, and from the ten top-ranked models, RMSD values of structures analyzing the quality of the resulting systems (Figs. **7-9**). The initial compatibility helps us investigate intermediates' binding mechanism and 3-D structure in forming a biocompatible complex (Figs. **10-12**).

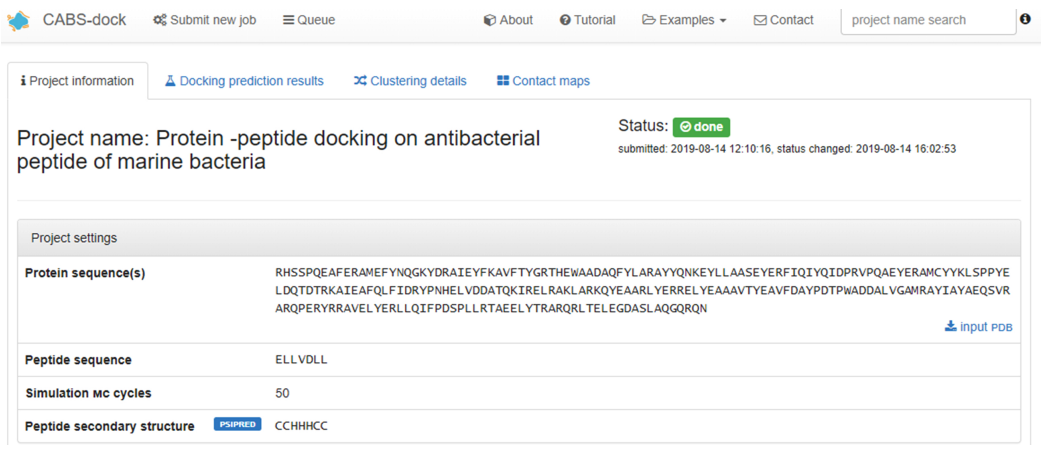

Fig. (1). CABS Dock Layout.

Fig. (2). Multiple Models of Conformer Generation.

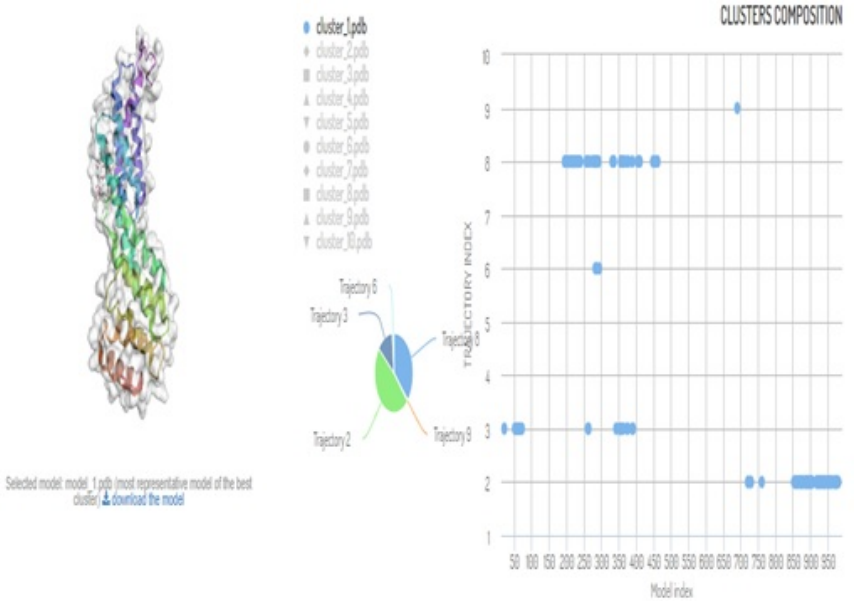

Fig. (3). Hierarchical Clustering of Multiple Models.

CHAPTER 6

Performance Evaluation of an IoT-Enabled Rapid Composter for Mixed Organic Wastes

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Abstract: By transforming organic wastes into nutrient-rich bio-manure and minimising other environmental effects, composting enables the long-term management of organic wastes. Traditional methods of monitoring and process management present a number of challenges in terms of efficiently using available resources to produce high-quality compost. As a result, smart composting technologies must be introduced to make it feasible for small-scale units in urban areas as well as large-scale operations in outlying areas. By analyzing recent trends in digital-based design and development, the current study explores the reach of digitalization in bringing user-friendly solutions, such as the internet of things (IoT)-based rapid composter. Using sewage sludge and other organic wastes in a stainless steel concentric bin type adiabatic rapid composter with provisions for thermal control (glass wool), feeding and mixing, leachate recirculation, and an online data monitoring system (Arduino kit) using particular sensors, the composting trials were carried out. More than 25% of the control bin's temperature was preserved by the insulator. Within 28 days of treatment, stable and mature compost was produced as a consequence of the online monitoring system's observations of temperature, moisture content, and pH steering for the best aeration and rotating frequency.

Keywords: Adiabatic, Compost, Insulator, IoT, Organic waste.

INTRODUCTION

The modern world is witnessing a quiet, smart revolution, with increasing technological advancements affecting all aspects of life. Smart technologies, which are at the heart of digital revolutions, have dramatically influenced the architecture of the internet of things (IoT) as a central component of the latest industrial revolution. The true prospects of IoT are so broad and profound that fresh insights into the ongoing growth of other areas, such as the engineering field, medical and agricultures are provided by revolutionary technology [1]. As

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social demand and conventional tastes arise from an educated society, the application of IoT in futuristic global design cannot be explained to the minimum. An outstanding example of this are the present technical developments in the fields of resource allocation, conservation, and management, notably in the area of waste management. A quick comment on modern waste management issues is worth mentioning here [2].

Despite having ample resources for collection, separation, treatment, and disposal, managing garbage has always been a difficult problem for the government and municipalities.In the context of solid waste management in urban development, a few major difficulties have been reported: (i) growing amounts of materials above all management design skills; (ii) real-world segregation problems; (iii) insufficient treatment facilities; (iv) poor financial support system; (v) not in my backyard syndrome (NIMBYism); (vi) lack of information and engagement; and (vii) inadequate coordination and involvement. On a fair-base examination, we can see that points (i.), (ii.) and (iii.) are more technologically-related, (iv.) economically-based and, (v.) (vi.) and (vii.) socially-related. The technological element depends on the effective separation of materials and the appropriate pre-treatments (if needed) for the choice and success of correct treatment technology [3]. The primary difficulties, however, rely on societal considerations in order to achieve worldwide change in the conviction and attitude of the people.

The huge advancement in digital media in a highly populous country such as India has always favored a reverse business multilevel model that shows that with the advent of instant communication through information technology, even a small change can make a major difference in the life of large number of people [4]. In the context of Indian sustainable solid waste management programs, it is evident that social factors must be addressed through good communication and advocacy, so that technical implementation can work successfully for its design life. And it is not unexpected that India has tremendous potential for solid waste production (approximately 250 million tonnes per year) [CPCB 2017] and for efficient recycling of resources. The significance of new techniques such as IoT in tackling common waste management challenges is therefore crucial to comprehend.

Composting technique has been acknowledged as an organic solution for the urban solid, industrial and agricultural waste components. The impact of the reduction of pollution (lower outside disposal, greenhouse emissions and subsoil waste) and increasing edge advantages (crop output, availability of soil nutrients and soil restorations) are reported to be substantial in the environment [5]. Composting techniques are more conventional and small-scale in rural regions, whereas composting practices in metropolitan areas are more inventive and broader.

The main difference is that even though a proper monitoring system has been operational effectively, it has not yet been adequately built in distant areas. Control is also largely dependent on conventional tools and procedures in urban composting systems. Since compost consistency dictates its stability and applicability, there is a considerable opportunity for more advances in large-scale compost monitoring.

IoT-Enabled Bins

As a futuristic recommendation for effective waste management, ‘smart composting' is found to be the most demanding technique, where it allows IoT applications and automation by minimizing the inefficiencies of physical monitoring and the other issues listed above. Aerobic in-vessel composting devices (composters) are favoured as the best reactors for preparing compost in urban areas because they save space and produce fast, stable bio-manure. There are few studies available in the literature that cover the spectrum of smart composting in real-time applications. Since this is an interdisciplinary field, an integrated approach is needed to overcome the natural barriers to identifying the required research components by defining the relevant technological attributes from both the physical and digital sciences of composting and IoT. Consequently, the current study focused on preparing compost from sewage sludge and other organic waste in a short span of time using an IoT-enabled smart rapid composter unit. It also emphasizes the optimization required for the rapid degradation that includes (i) feed selection (ii) moisture content (iii) temperature and (iv) pH.

MATERIALS AND METHODS

Design and Fabrication of Smart and Rapid Composter

Setting Up of Rapid Composter

A concentric bin type rapid composter uses stainless steel for thermal control (glass wool), feeding and mixing, leachate recirculation and an online data monitoring system (Arduino kit) using specific sensors. The details of the rapid composter unit are shown in Fig. (**1**).

Installation of Microcontroller

The Arduino UNO is a microcontroller board. It has ATmega328P IC (Integrated Circuit), 14 digital input/output pins (in which 6 pins are PWM (Pulse with Modulation) outputs), 6 analog inputs, 16MHZ quartz crystal, a USB connection, an ICSP (In-Circuit Serial Programming) Header, a power jack and finally a reset button. It is used to control the sensors and it gets the output of the sensor and the

CHAPTER 7

Design and Analysis of Position Sensorless Brushless DC Motor Drive

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Abstract: This paper presents the study of a position sensorless Brushless DC Motor drive. Back emf detection is proposed to avoid the conventional methodology of rotor position sensing. An equivalent mathematical model of a Brushless DC motor is developed to obtain various parameters required for more accurate control of the drive. The analysis of the modelled drive is performed through simulation results at various speed steps suitable for adjustable speed drive. The drive suggested with a PID controller, equivalent mathematical model and Back emf detection provides a quick and efficient steady state performance during speed changes. Hence, due to the advantages of compact size, Quick response and overcoming conventional position sensing-based drawbacks, this drive is very well-suited for adjustable speed applications.

Keywords: Adjustable speed drive, Back emf detection, Brushless DC motor, Mathematical model, Matlab simulation, PID control.

INTRODUCTION

Over the last decade, a broad range of adjustable speed Brushless DC motor (BLDCM) drive applications are made available due to the development in power semiconductors, microcontroller technologies, *etc.*, enabling reliable and cost-effective solutions. Reliability of BLDCM drives reduces due to the conventional Hall sensor based rotor position sensing. Also Hall sensor's performance is greatly affected when applied at high temperature environments.

Virtual neutral point (VNP) method is preferred among other back emf zerocrossing detection techniques as VNP is more reliable and accurate [1 - 7]. A

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mathematical model of a BLDCM is required as more parameters are required to for VNP based back emf sensing technique and implementation of PID controller in the drive. Conventional BLDCM simulation tools have fewer output parameters and require complex calculation of other parameters for the proposed scheme. The state space model of a BLDCM helps to derive additional parameters enabling an accurate and simple description of BLDCM [8]. Various proposed schemes with transfer function models of BLDCM in previous works [9] have certain limitations and are restricted to single input single output and zero initial condition systems only. Thus a state space model is developed providing required multiple outputs for easier control and versatility to develop user-defined blocks in simulation and simultaneously during implementation. Moreover, the potential at a virtual neutral point can be easily determined using the state space model.

The key features of a conventional PID controller algorithm are it is easily adjustable, has a steady operation and simple design, which make it widely used for the controlling system. PID control is a reliable technique with proper tuning for all linear systems. Tuning a PID controller is challenging and therefore a set of values is applied for the PID controller's constant coefficients, Kp, Ki and Kd. A basic circuit diagram is shown in Fig. (**1**) for the BLDC motor.

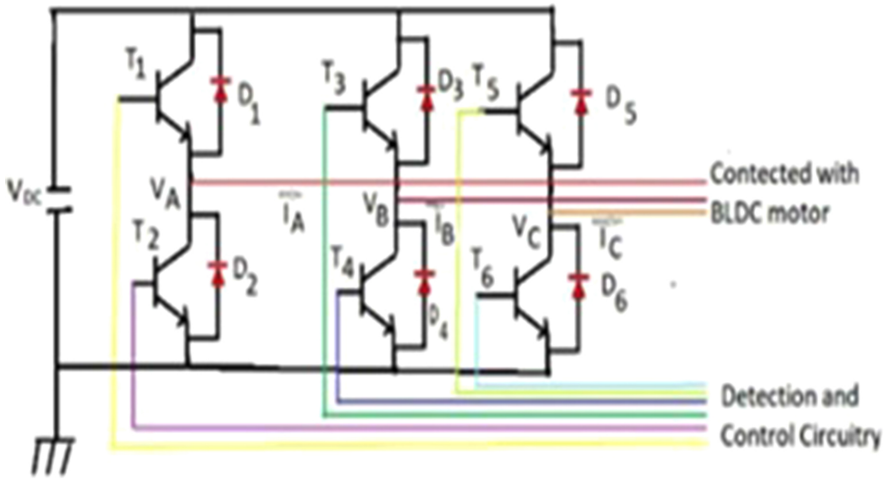

Fig. (1). Basic Circuit Diagram.

This proposed study shows that rapid tuning of the PID controller can control the speed of the motor as well as maintain a constant speed during load changes thus making it suitable for adjustable speed drives.

Modelling of PM BLDCM

A star wound three-phase symmetrical stator arrangement is assumed (Fig. **2**).

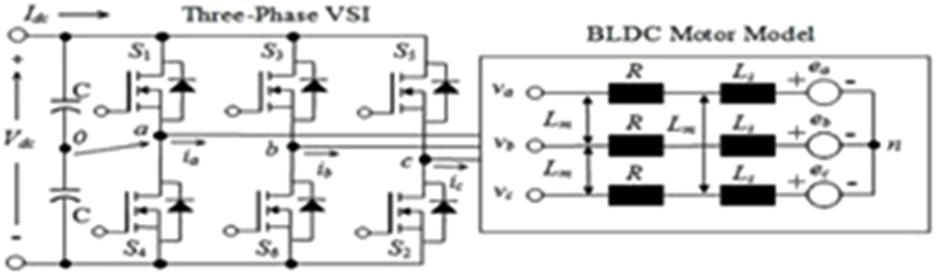

Fig. (2). Equivalent Circuit of BLDCM.

Let L1 = Ls − Lm be the motor's winding inductance (H), and e_a, e_b, and e_c be voltages of back emfs. The matrix representation of this system is given as:

$$\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} = \begin{bmatrix} R & 0 & 0 \\ 0 & R & 0 \\ 0 & 0 & R \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \begin{bmatrix} L_s - L_m & 0 & 0 \\ 0 & L_s - L_m & 0 \\ 0 & 0 & L_s - L_m \end{bmatrix} \frac{d}{dt} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \begin{bmatrix} e_a \\ e_b \\ e_c \end{bmatrix} \quad \textbf{(1)}$$

where v_a, v_b, and v_c are voltage (V) at phase *a, b & c, respectively* .

The instantaneous induced emfs can be expressed as,

$$e_a = \text{fa}(\theta)\ \lambda\ \omega \quad \textbf{(2)}$$

$$e_b = \text{fb}(\theta)\ \lambda\ \omega \quad \textbf{(3)}$$

$$e_c = \text{fc}(\theta)\ \lambda\ \omega \quad \textbf{(4)}$$

The peak value, Ep is derived as,

$$\text{Ep} = (\text{B l v})\ \text{N} = \text{N}\ (\text{B l r}\omega) = = \text{N}\ \varphi\omega = \lambda\ \omega \quad \textbf{(5)}$$

Where N is the number of conductors in series per phase

V is the velocity, m/s

L is the length of the conductor, m

R is the radius of the stator bore, m

CHAPTER 8

Study of Physical and Chemical Properties of High Energy Storage Bio Polymer Materials

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Abstract: Some physico-chemical properties of hyperbranched poly([1,2,3]-triazol--[1,3,5]-triazine)s synthesized by thermal azide-alkyne cycloaddition of AB2 and A2B monomers were studied by DSC, TGA, SEC and other methods. Density, thermal stability, shock and friction sensitivity were determined. The combustion heat of monomers and polymers, which was also defined, was used to compute their heat. The thermodynamical compatibility of polymers with various plasticizers was investigated by the micro-interference method in the temperature range from 20 °C to 100 ° C. The phase state diagrams were plotted based on the mutual solubility of polymers with plasticizer's data. The interdiffusion coefficients were found in a wide range of temperatures and solution compositions of investigated systems. Hyperbranched poly([1,2,3]-triazole-[1,3,5]-triazine)s are the perfect building blocks for the creation of innovative energy materials because of their unique features.

Keywords: Density, Heat of formation, Hyperbranched poly([1,2,3]-triazol--[1,3,5]-triazine)s, Plasticizer, Sensitivity, Stability, Thermodynamic compatibility.

INTRODUCTION

These potent polymers are used as solid rocket propellants or as gun powders. However, the further introduction of energetic polymers is constrained, both for economic reasons (raw materials expensive, long and painstaking synthesis), and due to the fact that often the level of physical and mechanical properties of the synthesized high-enthalpy polymers is not high enough.

The employment of energetic hyper branching polymers(HBP) is one potential answer to the issue of a combination in high binding energy, technological, physical, and mechanical qualities.

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It is important to be aware of the potential for altering the characteristics of hyperbranched polymers by chemical alterations, adjustments to the circumstances of manufacture, changes in the level of polymerization, *etc.* Nevertheless, a limited number of energetic HBPs have been synthesized [1 - 2]. Besides, the diffusion and self-diffusion coefficients of HBP, details of which are necessary to create new compositions, have been measured only for few dendrimers. The aim of this work is to study the complex physical and chemical properties of the obtained hyperbranched polymers depending on the structure of terminal groups [3 - 4].

EXPERIMENTAL

Hyperbranched poly([1 - 3]-triazole- [1, 3, 5]-triazine]) with terminal triple bonds (Pado) was used as the test object, as well as hyperbranched poly([1 - 3]-triazole-[1, 3, 5]-triazine] with terminal azide groups (Pdao) obtained by the reaction of 1,3-dipolar cycloaddition (DCA) of the monomer 2,4-diaStructures of the obtained polymers are shown in Fig. (**1**).

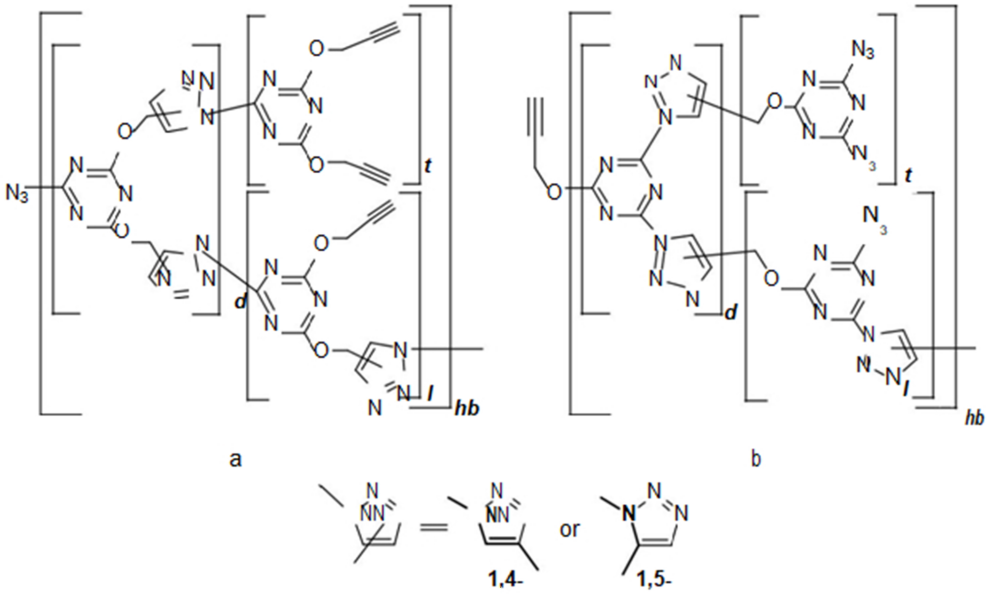

Fig. (1). Structures of Pdao (a) and Pado (b).

Hyperbranched polymers have been synthesized in the absence of solvent at 80 °C. The molecular weight, estimated by exclusion liquid chromatography with the calculation based on the light scattering detector data, amounted to Mn = 15200, Mw / Mn = 2.8 and Mn = 78000, Mw / Mn = 12.4 for Pado and Pdao, respectively

[6 - 8]. The relaxation transitions study of polymer systems was carried out by DSC in a temperature range of - 75 - +150 °C, under nitrogen at a scan rate of 10 °C·min-1. We used a differential scanning calorimeter METTLER TOLEDO DSC822e. The decomposition study was carried out by TGA 851 in a temperature range of 0 - +300 ° C at a scan rate of 10 °C·min-1.

The interdiffusion processes were studied by microinterferometry in the temperature range of 20-100 °C. Experiments were performed at temperatures not higher than 100 °C because of the possible degradation of components.Heat of formation was obtained by calorimeter BKS-2X. Shock sensitivity and friction sensitivity were estimated by drop-hammer K-44 end K-44-III, respectively.

RESULTS AND DISCUSSIONS

The heat of formation of Pdao is equal to 2525 kJ-kg-1, density ~ 1600 kg-m-3, sensitive to shock is 0% (50 mg weighed, load 5 kg, height 10 cm) and 100% (50 mg weighed, load 5 kg, height 25 cm).

Thermal effects were not detected on DSC thermograms in the range of -75 to 140 °C. De-composition occurs instantly by heating. Curves showing the dependence flash point *vs*. heating rate relationship are given in Fig. (**2**).

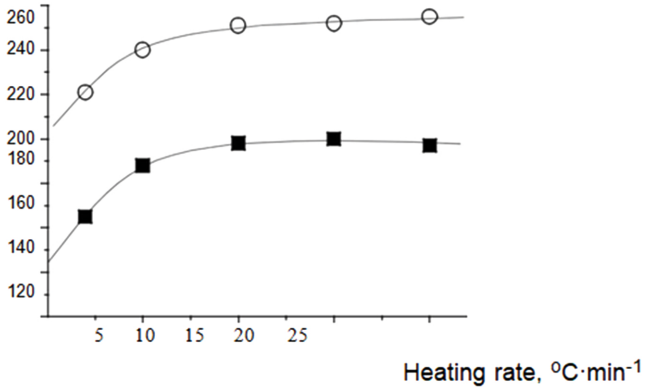

Fig. (2). Temperature of flash point related to heating rate. 1 - Pado; 2 - Pdao.

The thermodynamic compatibility of Pado and Pdao with various plasticizers has been studied. The traditional solvents - adiponitrile (ADN), glycerin triacetate (TAC) and dibutyl phthalate (DBP) were used as plasticizers. Both polymers are limited and compatible with the present plasticizers. (Fig. **3**) shows the concentration limits of the compatibility of the Pado with plasticizers.

CHAPTER 9

Design of CNT Polymer Composite Based Strain Sensor to Study the Effect of Humidity and Electrical Conductivity

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Abstract: The high electrical conductivity of carbon nanotubes(CNTs) has motivated their incorporation into polymers for several purposes, including electrical conductivity enhancement and sensing. Some studies have suggested that thin films of CNT/polymer composites canbeused for humidity sensing. This study focuses on the influence of humidity on the electrical conductivity of CNT modifie depoxy composite. The degree of sensitivity to the humidity of the developed composite is compared to other sensing capabilities (strain and temperature). It was found that a change in humidity from 5% relative humidity (RH) to 95% RH can cause an 80% reduction in conductivity. This significant reduction must be considered if a CNT-based strain sensor is to be developed. A gauge factor of 3.7 was obtained for CNT-epoxy strain sensor suggesting ~4% change in conductivity as a result of 1% strain. This suggests that a modest change in humidity can completely compromise the accuracy of CNT-based strain sensors.

Keywords: Carbon nanotubes (CNTs) Single-walled CNTs (SWCNTs), Multi-walled carbon nanotubes (MWCNTs), Polymethyl methacrylate (PMMA).

INTRODUCTION

Carbon nanotubes (CNTs) have greatpotential forenhancing the electrical conductivity of different polymers [1]. Such nano-modification is effective inaddressing issues associated with electrostatic charging, electromagnetic interference and possibly lightning strike. Further, the electrically conductive network of CNTs can be used for health monitoring and sensing applications (*e.g.*measuring strain and matrix damage) [2]. Several studies have shown that CNT networks are piezo-resistive (*i.e.*, strain change in the nanocomposite is proportional to electrical resistance change). Thus, strain sensing of apolymeror

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composite is conceptually possible through the incorporation of CNTs into a polymer composite structure [2 - 3]. Dimensional changes of the polymer barrier between CNT-CNT junctions in nanocomposites due to strain are at least partly responsible for the piezo-resistivity of CNT composites [4], suggesting that humidity and temperature induced dimensional changes would also affect the conductivity of CNT networks. This is the reason why various research work have focused on the possible use of CNT networks embedded in polymers for humidity sensing [5 - 7]. The actual cause of the CNT networks' sensitivity to humidity is debatable. According to Yoo *et al.*, the swelling of polymers below the percolation threshold and the charge transfer of water molecules to CNTs over the percolation threshold are what induce variations in resistivity. However, assertions that the water molecules generate a charge transfer are refuted by density-functional calculations done by Sung *et al.* [9]. They assert that this charge transfer modifies Fermi levels, increasing resistance across CNTs and across CNT-CNT junctions [8]. According to Yu *et al.* [7], the reduced conductivity of CNTs produced by water absorption is due to a weak link between the H and C atoms of the water and the CNTs, respectively. For a CNT/poly (Dimethyldiallyl-ammonium chloride) film, Liu *et al.* developed a model of resistance with respect to humidity, identifying three different parameters that affect the nanocomposite resistance (tunnelling barriers between CNTs, matrix swelling, and charge transfer from water to CNT) [10 - 11].

Xu *et al.* It has been hypothesised [12] that only water molecules may supply electrons to CNTs and reduce the number of conductive holes in CNTs. The main mechanism of conductivity change due to humidity for KOH doped MWCNT/PMMA film sensors was identified as a compensation of p-type MWCNTs by water-donated electrons [5]. The environmental factors can affect the overall electrical conductivity of a polymer nanocomposite for applications in which a certain level of conductivity is required. Therefore, it is essential to evaluate the impact of environmental conditions like humidity on the electrical conductivity of CNT composites, regardless of whether a CNT network is employed for sensing (strain, damage, *etc*.) or electrical conductivity augmentation. In order to stress the significance of this research, the findings are compared to the sensitivity of the same CNT-based epoxy film to strain. This work focuses on quantifying the influence of humidity and temperature on the electrical conductivity of a CNT-modified epoxy.

EXPERIMENTAL SETUP

MATERIALS

Single-walled CNTs (SWCNTs) were produced using the two-laser approach developed at NRC, as previously mentioned [13 - 16]. As-produced, unfunctionalized SWCNTs were incorporated into the epoxy adhesive system using a solvent-processing approach, which involves dispersion SWCNTs by ultrasonication, adding dissolved epoxyresin, and then solvent removal. Resin curing was finished at room temperature, yielding composites with a SWCNT loading of 1 weight percent. The removal of freestanding films was made easier by curing films of baseline and nanocomposite epoxy resin with a thickness of 0.1 and 1 mm between two glass plates covered with a release agent. Shims made of metal were inserted between the two plates to regulate the film thickness. (Fig. **1**).

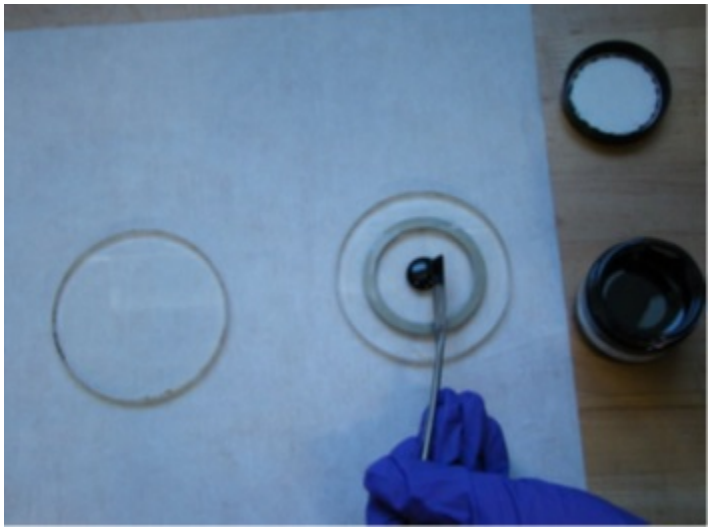

Fig. (1). Manufacturing of thin films using a steel shim and two glass substrates.

TEST SETUP

A DVS Advantage Dynamic Gravimetric Vapor Sorption Analyzer from Surface Measurement Systems was used to expose tiny samples with lateral dimensions of around 4 mm to humidity in order to measure the weight increase of the polymer and nanocomposite thin films as a result of humidity. By measuring the current at a nanocomposite film, the in-plane electrical resistance of the films was determined.

The effect of temperature on the electrical conductivity of the nanocomposite (0.1 mm thick film) was also studied. For the electrical measurements, strips of 5 mm

CHAPTER 10

Characteristics of Bridgeless Boost Converter Fed Bldcm and Improvement of Pf Under Different Loads

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Abstract: This chapter describes the Power Factor Correction (PFC) Bridgeless (BL) Boost converter fed BLDC motor drive as a cost-effective solution for low-power applications. A BL configuration of the boost converter is proposed, which offers the elimination of the diode bridge rectifier, thus reducing the conduction losses associated with it. A PFC BL boost converter is designed to operate in Discontinuous Conduction Mode (DICM) to provide an inherent PFC at mains by using the ANFIS-PID controller. The performance of the proposed drive is evaluated over a wide range of speed control and varying input supply voltages (universal mains at 90–230 V) with improved power quality at AC mains. The obtained power quality indices are within the acceptable limits of international power quality standards such as the IEC 61000---2. The performance of the proposed bridgeless boost converter fed BLDC motor drive is simulated in MATLAB/Simulink environment. The measured simulation results of THD are reduced to an optimum value of 2.51 for the 400V DC link. Also, the observed results are compared and used to improve the power factor unity according to the variation of the DC link voltage.

Keywords: ANFIS-PID, BLDCM, DICM, PFC.

INTRODUCTION

Akash Varshney *et al*. (2017) presented the performance of a BLDC motor with various kinds of loads and used various control strategies to demonstrate that BLDC motors are a viable alternative to traditional motors such as Induction Motors, Switched Reluctance Motors, *etc.* [1, 2]. An advanced Fuzzy PID controller is compared with the commonly used PID controller in terms of dynamic speed response of the motor at the time of application as well as at the time of removal of the load. The major drawback of the BLDC motor is the jerky

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behavior at the time of load removal. The speed torque characteristics reveal the fact that the jerks are minimum at the time of gradual load removal with a Fuzzy PID controller in place. These jerks are defined by the 'Perturbation Window'. Alejandra de la Guerra *et al.* (2018) developed an Active Disturbance Rejection Controller (ADRC) for the permanent magnet brushless DC motor. Compensating for the load torque variations in the rotor shaft does not require the measurement of the rotor shaft speed. The controller is easy to implement and tune. The proposed scheme compensates for the load torque variations while reconstructing the speed shaft [3].

Lokesh Kumar Agrawal *et al.* (2018) presented that due to reliability, high efficiency, high starting torque, and less electrical noise, brushless DC motors are widely used for many industrial applications. For the speed control of the BLDC motor, different controllers are used. In this chapter, the performances of the BLDC motor have been tested without a controller and with conventional controllers PI and PID. The results have been compared with fuzzy-based controller. Fuzzy controller gives an effective speed response, but conventional controllers provide a better response with changing load. The model is simulated with MATLAB/SIMULINK [4]. Baran Hekimo.LU (2019) determined the optimal parameters of the Fractional-Order Proportional Integral Derivative (FOPID) controller for dc motor speed control, an Atom Search Optimization (ASO) algorithm and a novel chaotic version of it [Chaotic ASO (ChASO)]. The ASO algorithm is simple and easy to implement, which mathematically models and mimics the atomic motion model in nature. It is developed to tackle a diverse set of the optimization problem. The numerical simulations of the proposed ChASO-FOPID and ASO-FOPID controllers for the DC motor speed control system establish the superior performance of both the chaotic ASO and the original ASO [5 - 7].

The converter functioning, at different load conditions where the power conversion process would be quick, would be reflected in the switching device. Due to load variation, the immediate response of solid-state components operate at a different frequency with ON and OFF at short time interval. The energy storage elements can lead to an increase in the complexity of converter design for an efficient power conversion process [8]. This can be reminded by using a higher switching frequency which reduces the size of the components used in the converter circuit design. But a sudden change in the switching frequency leads to an increase in the switching losses and decreases the total efficiency of the output. The BLDC motor drive usually inputs supply quantity which has a higher order harmonic distortion and which may affect the operating performance of the drive. In this research work, it is designed and implemented in such a way that the bridgeless boost converter is controlled by the ANFIS-PID controller [9, 10].

The operation of the ANFIS-PID controller generates a suitable switching sequence to the BL-Boost converter and produces variable DC link voltage for the better operation of the BLDC motor drive. The objective of this research is to develop an ANFIS-PID controller which is implemented in the BL-Boost converter to operate and to reduce current harmonics in the BLDC motor drive system. Based on the different modes of operation, the Power Factor Correction (PFC) converter faces some critical operating issues which directly affect the cost and rating of the components employed in the PFC converter. There are two popular techniques available in the BLDC motor drive. They are Continuous Conduction Mode (CCM) and Discontinuous Conduction Mode (DCM). In the operation technique of CCM, the inductor current or the voltage across the intermediate capacitor remains continuous and transfers the power to the load.

The operation of the CCM requires two voltage sensors, but the DCM operation requires only one voltage sensor on the input side. The implementation of the DCM in BL-Boost converter fed BLDC motor drive reduces the overall cost and minimizes the switching losses. The application of the conventional BLDC motor drive system is operated in Pulse Width Modulation (PWM) technique with voltage source inverter for producing constant DC link voltage in the absence of a converter. In this scheme of operation, it produces higher switching losses due to the absence of a suitable controller and affects the normal operation of the BLDC motor drive. In the presence of the BL-Boost converter in the BLDC motor drive system, variable DC link voltage is attained and smooth speed control is achieved. The voltage source inverter operates with fundamental switching frequency and reduces the switching losses using electronic commutation technology.

MODELLING AND SIMULATION ANALYSIS OF BL-BOOST CONVERTER FED BLDC MOTOR DRIVE

The proposed ANFIS-PID controller operated with BL-Boost converter-fed BLDC motor drive has been developed to decrease the harmonic content and improve the power quality at the AC mains. The new approach of the BL-Boost converter is modified in our research, based on the suitable design value of inductors and capacitors. The newly designed BL-Boost converter fed BLDC motor drive MATLAB Simulink model is analyzed in detail with the various performance characteristics. Moreover, the bridgeless configuration of the boost converter offers low conduction losses due to the partial elimination of diode bridge rectifier at the front end. The simulation results are implemented by using a MATLAB/Simulink environment.

CHAPTER 11

Power Transmission in Multiple EV Using Harris Hawks Optimization-based SOC Balancing Technique

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Abstract: This article proposes the Wireless Power transfer technique in electric vehicle charging using the Dual Active Bridge (DAB) system. The source end of the primary coil is connected with a constant high-frequency DC-DC converter with capacitive compensation, and the secondary coil is connected with capacitive compensation in moving electric vehicles (EVs). A transformer is used to improve the input power, and a compensating capacitor is used to reduce the amount of current leakage. Here the FOPID controller is regulated using Harris Hawks Optimization (HHO) Algorithm which is based on the SOC balancing technique. The analysis of the proposed topology for three different vehicles with different power classes is described in detail. The proposed system is implemented, and output performance will be analyzed in MATLAB/SIMULINK.

Keywords: Battery charging, Constant Current- Constant Voltage (CC-CV), Dual Active Bridge (DAB), State of charge (SOC), Wireless power transmission (WPT).

INTRODUCTION

This article introduces the wireless transmission function for charging multiple electric vehicles (EVs) using a Dual Active Bridge (DAB) fast charging system [1 - 4]. The proposed system is used to transfer power in a wireless manner to charge three types of electric vehicles having different power ratings simultaneously by using DC voltage. The module of the proposed structure consists of a modified high step-up non-isolated DC-DC converter, Dual active bridge converter with high-frequency transformer, and Buck converter [5 - 8]. The buck converter is fed to the battery of electric vehicles. The circuit diagram is shown in Fig. (**1**).

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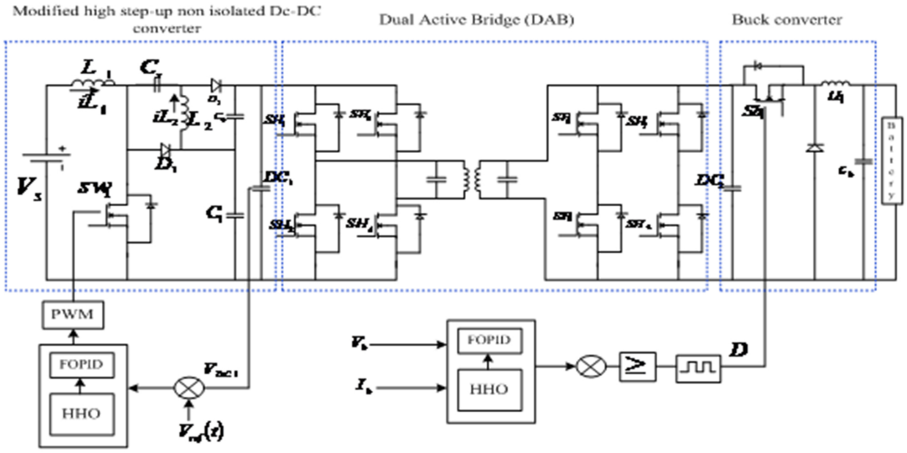

Fig. (1). Circuit diagram of the proposed system.

HHO ALGORITHM FOR OPTIMIZATION

An algorithm is needed to find the following: (1) Find the best solutions for calculating battery resistance and SOC, (2) Flexible performance and size, (3) Calculate the test number or model and the degree of disability. The flow chart of the algorithm is shown in Fig. (**2**).

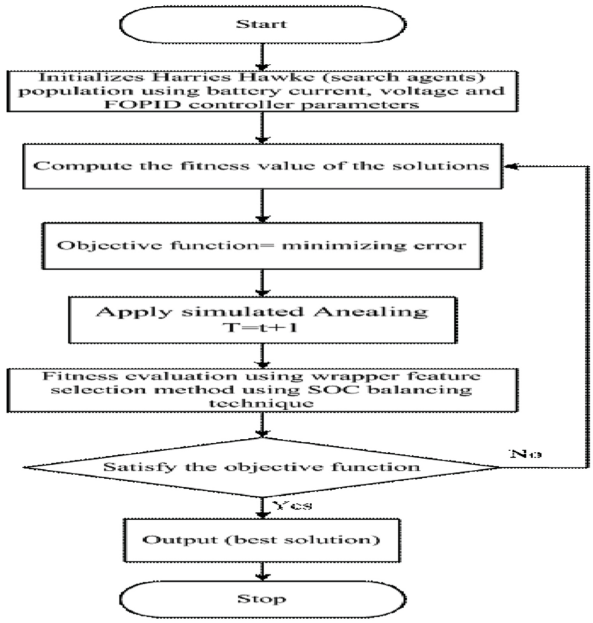

Fig. (2). Circuit diagram of propsed system.

SOC BALANCING TECHNIQUE

The battery topology operation revolves around the level of State of Charge (SOC). For wireless power transmission, the operating conditions of the high-frequency fast-charging circuit and the inverter must be defined, and the required SOC level configuration is taken into account. Thus the battery charges or discharges according to its SOC level.

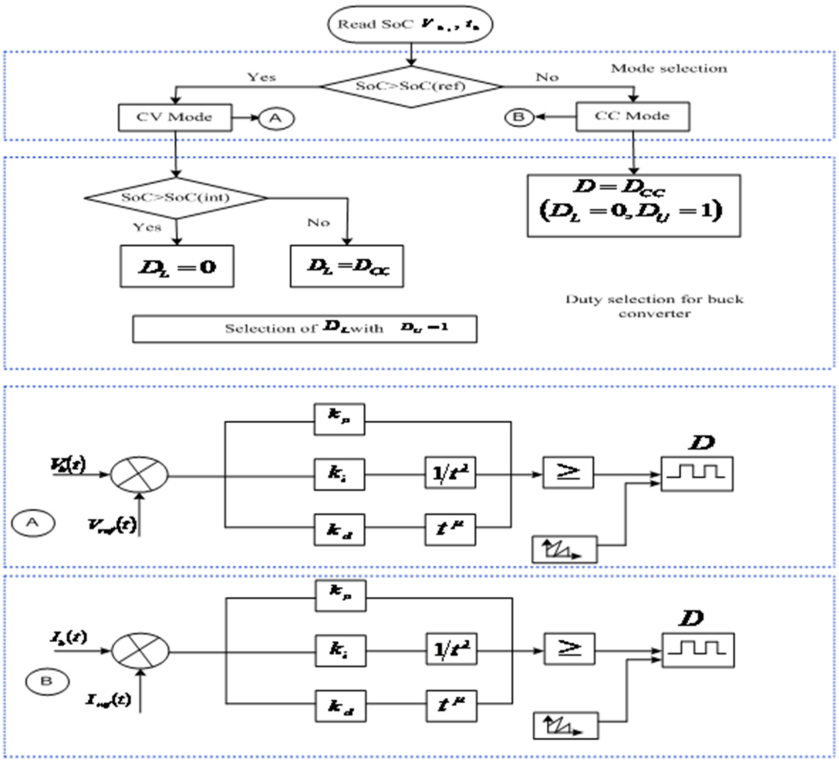

Fig. (3). Flowchart for charging EV with CC and CV control mode.

The battery calculation is intended to work in such a manner, if the SOC value is below the reference SOC, then the three power rating of different electric vehicles gets charged simultaneously in CC mode operation. Thus the G2V operation is performed. In the current operating mode (CC), the current battery is stored in the control system. The battery power reference is selected based on the current SOC value. To calculate the current battery error, the current battery value is compared to the reference value of the battery life. The error is given to the FOPID controller to generate a set of duty cycles. Once the SOC limit is reached, the operating system becomes a continuous power. At this point, the voltage at the discharge output remains constant and the current battery begins to decrease

CHAPTER 12

Effect of Disc Offset Distance on Transverse and Torsional Vibration of Rotor Shaft

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Abstract: Vibrations play a very important role in rotor systems. In the manufacturing of the rotor system, the imbalance caused by the offset impeller and eccentricity produces unwanted vibrations. Various studies were carried out on unbalanced factors of rotor systems like eccentricity, crack, *etc.* But the effect of impeller offset due to manufacturing fault is not given much attention. In this study, the change in natural frequencies with respect to disc offset distance was calculated using numerical analysis and experimental analysis for the steel Jeffcott rotor system. Finite element analysis of the offset rotor shaft is carried out in the ANSYS workbench. Experimental modal analysis is carried out using the DAQ system. The accuracy of the model and the solution technique has been observed by comparing experimental results with the numerical simulation results from ANSYS. It is observed that when the disc is shifted from the center, it has a significant effect on transverse and torsional vibrational frequencies. As the disc is shifted towards bearing supports, the stiffness of the system increases, which leads to an increase in vibration frequency.

Keywords: Effect of disc offset, Experimental modal analysis, Jeffcott rotor system.

INTRODUCTION

Vibration is the branch of dynamics that deals with repetitive motions. Vibrations can be useful in some cases, and they can be destructive in some cases. For musical instruments, vibration is desired. And for mechanical systems and structural systems, it is destructive. Having good knowledge of vibration can produce beautiful music from the strings of the guitar. On the other hand, vibration can be damaging, and the best example of that is the earthquake Vibrations play a very important role in the rotor systems. And with rapid

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technological advancements, rotor systems such as motors, jet engines, pumps, turbines, and automobile engines are frequently subjected to high speed-operating environments to match the production expectations [1]. Unwanted vibrations are caused in the rotor system due to imbalance, offset impeller, and eccentricity caused by manufacturing faults in high-speed rotor-bearing systems. In this, the most harmful vibrations are mainly lateral and torsional vibrations since they can destroy lubrication systems, bearings, and seals, which results in a full failure of the rotating machinery, affecting the rotor-regular system's operation [2].

Mathematically, vibration is modeled based on fundamental principles, and by solving calculus, differential equation vibration can be analyzed. Vibration in the system is the result of a change in potential energy into kinetic energy. In a vibratory system, one of the components stores potential energy, and in the form of vibration, the kinetic energy is released [3]. Springs and Flywheels are examples of mechanical energy storing components; hence they tend to vibrate.

Many researchers have accomplished analytical and numerical analysis for investigating lateral and torsional vibrations with different exciting parameters such as unbalance, fatigue, eccentricity, crack and offset of the component to make these systems work with normal operation, efficiency, and safety [4]. Huge economic losses are caused because of its failure in heavy machinery. In the industry, the fundamental problems are fatigue failure of shaft and impeller [5]. Moreover, for assurance of the safe working of turbo machines and to support strong research on relevant fundamental scientific problems, the study of the vibration analysis of rotor shafts is beneficial. For the design and control of rotating equipment, proper understanding of vibration dynamics is needed.

Different methods have been used in exploring rotary systems. To study the behavior of vibratory systems, the Jeffcott rotor model is used. The Jeffcott model for rotors assumes having a rigid rotor on a massless shaft. The effect of rotary inertia and gyroscopic effect is not considered [6]. In this study, to find analytical results, the influence matrix method is used. Derivation for the general influence matrix method for the rotor response due to offset distance is studied.

The mathematical model creation and numerical simulation are used to do a transverse and torsional modal study using the Jeffcott rotor system for different disc offset distances under free vibration [7]. The influence matrix method is used to build the mathematical model which governs the transverse and torsional vibration of a rotor shaft. From the mathematical model, natural frequencies of the rotor system for different offset distances are determined. Further, FE analysis is carried out in ANSYS for modal analysis for different cases. A comparison is made between the Finite Element method results and mathematical results which

are found using the Influence matrix method. With the help of results, the effect of disc offset on torsional and transverse vibration frequency is studied.

EXPERIMENTAL MODAL ANALYSIS

Experimental modal analysis is carried out on whirling of shaft setup as shown in Fig. (**1**), with the help of the DAQ system for different disc offset conditions as shown in Tables **1** and **2**, systems frequency response is recorded. And by using this data, the graphs of frequency *versus* amplitude are plotted as shown in Fig. (**3**).

Fig. (1). Experimental Setup.

Table 1. Material and Geometrical Parameters.

Material	**Mild Steel**
Shaft length	1120 mm
Shaft diameter	6.48 mm
Disc diameter	60 mm
Width	10 mm

Table 2. Different Disc Offset Conditions.

Case No.	**Disc Position**	**Offset Conditions**
1	Disc at center	a = b = 560 mm
2	Disc offset by 100mm from center	a = 660 mm, b = 460 mm
3	Disc offset by 200mm from center	a = 760 mm, b = 360 mm

CHAPTER 13

Modeling and Characterization of Carbon Nano Tube Nanocomposites

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Abstract: The interfacial sliding motion of carbon nanotubes (CNTs) within a polymeric hosting matrix gives rise to energy dissipation. By tuning the interfacial shear strength (ISS) of the CNT-matrix interface, the dissipation can take place within tunable ranges of strain amplitudes. This is the basis for conceiving new multilayered carbon nanotube nanocomposites in which different layers with tunable ISS can lead to a concurrent optimization of strength and dissipation, often seen as two conflicting targets. Such optimization is tackled by a novel meso-mechanical nonlinear inelastic model proven to effectively predict the damping capacity of CNT nanocomposites. The proposed elastoplastic, rate-independent, constitutive theory is based on the mean-field homogenization method which combines the Eshelby equivalent inclusion method, the Mori-Tanaka homogenization, and the concept of inhomogeneous inclusions with inelastic eigen strains introduced to describe the inelastic stick-slip. Since the ISS parameter plays a key role in the nanocomposite strength and dissipation, the current work seeks to improve the strength and damping properties by suitable interfacial CNT-matrix functionalization. Variations in the ISS parameter can be achieved by a functionalization that affects the chemical bonds between CNTs and the hosting matrix. A set of experimental tests - including DMA analysis, calorimetry and spectroscopy — aims to evaluate the influence of the ISS parameter, together with other constitutive parameters, on the nanocomposite strength and damping capacity.

Keywords: CNT functionalization, Interfacial shear strength, Nanocomposites, Stick-slip dissipation.

INTRODUCTION

Carbon nanotube nanocomposites are believed to have the potential to exhibit high damping capacity and excellent mechanical properties. The superior Young modulus of the carbon nanotube fillers enables a structural reinforcement when the load transfer is ensured by a strong interaction between the CNTs and the surrounding polymer matrix.

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On the other hand, high dissipation can be observed when a frictional sliding motion takes place through the high interfacial area, available between the CNTs and the polymer chains. This dissipative phenomenon at the CNT-matrix interface, known as a stick-slip mechanism, has been extensively studied [1]. The great potential of the CNT composites lies in the possibility to tailor the CNT/matrix interface, allowing for the design of a new class of lightweight materials with desired properties. Several studies highlighted the importance of various factors that can affect the behavior of such nanostructured materials, including the CNT dispersion their aspect ratio and alignment [2, 3], as well as the mechanical/thermal properties of the polymer matrix.

Short CNTs can facilitate the occurrence of the stick-slip phenomenon as well as the disentanglement during the fabrication process. At the same time, the orientation of the CNTs can improve the response of the material designed to work under specific loading conditions. On the other hand, the ability of the polymer chains to react with some functional groups or to interact with the aromatic rings of the CNTs surface is the key to tuning the interfacial properties. It can be safely stated that, together with the CNT weight fraction, the interfacial shear strength is the main factor affecting the nanocomposite response [4]. By acting at the nano-scale level and performing a proper chemical and/or physical functionalization of the CNT outer walls, it is possible to modify the ISS and optimize the macroscopic response of the material.

To optimize the complex behavior of the CNT-nanocomposite material, a novel meso-mechanical, nonlinear constitutive model has been developed to effectively predict the mechanical and dynamic response of nanocomposites [5]. Micro- and macro- constitutive parameters of the nanocomposites, such as the ISS, the CNT volume fraction and orientation within a multilayered composite, can be optimized to obtain a material with specific damping capacity and mechanical strength. Only a few works have dealt with experimental data on the mechanical and hysteretic damping behavior of nanocomposites [6]. The present work addresses the identification of the material model parameters through experimental tests and the actual feasibility of tuning these parameters through a carefully designed manufacturing/fabrication process of the nanocomposite material. Thus, a preliminary study on the influence of several key factors is carried out and a detailed study into the processing and manufacturing techniques and their influence on such key factors is provided.

MODELING CNT COMPOSITE

The nonlinear constitutive model adopted for the prediction of the CNT composite behavior shows the key role of the CNT volume fraction and the interfacial shear

strength. The employed mean- field homogenization method is based on the application of the Eshelby equivalent inclusion method and the Mori-Tanaka average stress/strain theorem. On the other hand, the introduction of an inelastic eigenstrain field in the CNT inclusions accounts for the occurrence of the interfacial stick-slip between the CNTs and the surrounding matrix. Indeed, this inelastic eigenstran has the aim to reproduce the local slip behavior occurring at the CNT-matrix interface. The effective stress driving the evolution of this inelastic component is the von Mises function of the interfacial stress jump.

The influence of the ISS parameter (Fig. **1**) is such that for relatively high ISS, the curve representing the nanocomposite damping flattens out over a wide strain bandwidth. A differential evolutionary-based optimization of the material parameters of the nanocomposite was carried out with respect to the CNT volume fraction and the ISS.

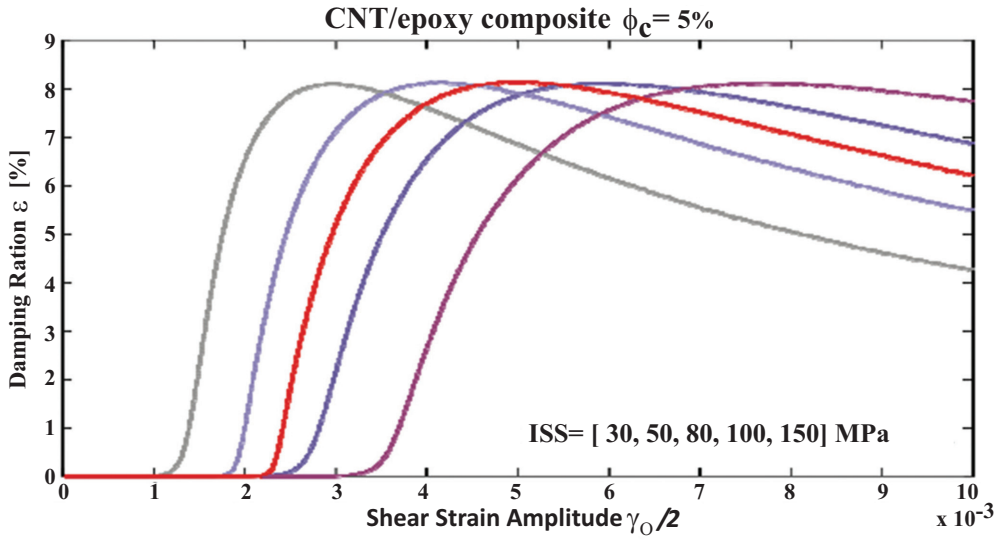

Fig. (1). ISS sensitivity in CNT/epoxy composites: damping ratio *vs*. strain amplitude.

The numerical results provided by the adopted nonlinear constitutive model have shown a good match with other complex molecular dynamic and micromechanical models [7]. Such a unique nonlinear meso-scale model needs a calibration of the material parameters based on sets of experimental measurements.

CHAPTER 14

Effect of Filler Material Type on Dynamic Behaviour of Composite Beams; an Experimental Study

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Abstract: The composite materials find various applications such as in turbine blades, helicopter blades, airplane wings, medical instruments, sports equipment, *etc*. They are subjected to a variety of dynamic excitations. The resonance condition is desirable for some applications such as vibration actuators, and musical instruments. And due to resonance, catastrophic failure may occur for most of the applications. Therefore, a study of dynamic behavior plays an important role in the design of materials either to avoid or to enforce resonance conditions.

This work aims at the experimental investigation of vibration characteristics of composite beams. In this work, composite beams were made of glass fiber and epoxy resin with varying filler materials and their percentage. Three filler materials, *viz*. Calcium Carbonate ($CaCO_3$), Nano-Clay, and Silicon Carbide (SiC) were considered for the study. The National Instruments Data Acquisition system (NI-DAQ) with a tri-axial accelerometer was used to acquire the vibration data. The natural frequencies of the beams were determined from the frequency domain data and damping ratios of the beams were determined from time-domain data. Effects of filler material type on natural frequencies and damping ratios were studied. According to the research, the damping ratio values drop in the order of $CaCO_3$, Nano-Clay, and SiC while the natural frequency values decrease in the order of Nano-Clay, $CaCO_3$, and SiC.

Keywords: $CaCO_3$, Nano clay, and Silicon Carbide, Composite beams, Damping ratio, Effect of filler material, Experimental Modal Analysis, Natural frequency.

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INTRODUCTION

Any repeated motion in a regular interval of time is called vibration. This theory of vibration deals with an investigation of the oscillatory motion of the bodies and the force associated with them [1]. The beam is a simple structure subjected to bending that finds many applications in long-span bridges, railways, supporting members for wide roofs in buildings, airplane wings, and so on. In most of the applications, they are subjected to vibration. If this vibration exceeds certain limits, beam breakage or failure will happen. Therefore, studying the effect of various parameters on dynamic behavior is very important [2]. In recent years, composites are used commonly in many diverse engineering fields. Composite materials are getting acceptance because of their great strength, resistance to corrosion, low weight, high fatigue strength and impact resistance [3].

The dynamic characteristics of structures can be described in terms of the modal parameters such as natural frequency, mode shape, and damping ratio [4]. The dynamic characteristics like natural frequency, mode shape, and damping ratio are studied through the experimental modal analysis [5, 6]. How the boundary conditions affect the free vibration of beams was studied [7, 8]. Free vibrations of composite beams were investigated [9, 10]. How the hybridization of composite beams affects the free vibration properties was studied [11]. The damping of the beams was studied for various composite materials [12, 13]. The damping ratios were determined using the logarithmic decrement method [14].

The effect of filler material such as nano-clay [15] and silica and calcium carbonate [16] on mechanical properties has been studied.

How the addition of borax affects vibration and damping for S-glass/epoxy composite laminates had been examined by Ahmet Erklig and Mehmet Bulut [17]. The influence of Nano-clay on the dynamic behavior of glass fibre reinforced vinyl ester composites was studied by J. Chandradass *et al.* [18].

Many of the researchers studied the dynamic behavior of metal beams and plates with different metals and alloys with different boundary conditions. Some of the researchers investigated the dynamic behavior of composite beams. To the best of our knowledge, the effect of filler material type on dynamic characteristics has rarely been studied in composites.

Therefore, in the present work, an attempt is made to study the effect of filler material type on the dynamic behavior of composite beams. The glass epoxy with different filler materials such as Calcium Carbonate ($CaCO_3$), Nano Clay, and Silicon Carbide (SiC) was considered for the study. The beam specimens of glass epoxy with 5% of $CaCO_3$, glass epoxy with 5% of Nano clay, and glass epoxy

with 5% of SiC were prepared and the effect of filler material on their dynamic behavior was studied.

EXPERIMENTAL DETAILS

The impact hammer test and vibration shaker test are the two types of experimental modal analyses. In this work, the impact hammer test method was used because of its simplicity and cost-effectiveness. The experimental setup for the free vibration analysis of the composite beams is shown in Fig. (**1**). The specimens of the composite beam were fixed to the fixture. A tri-axial accelerometer (356A15) was mounted on the test specimen using glue to fix it adequately. The accelerometer was then connected to the DAQ9234 module. By using an impact hammer, an initial disturbance was given to the test specimen. The DAQ9234 module on the c-DAQ 9178 chassis was connected to the computer with LabVIEW installed in it. A program was written in LabVIEW to acquire vibration in the time domain, to convert it into the frequency domain, and to save both for analysis.

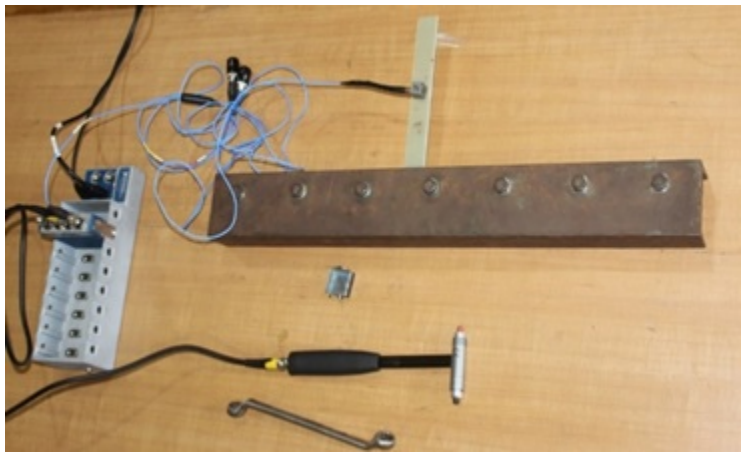

Fig. (1). Experimental Setup.

ii. Specimen Details

Glass-epoxy composite laminates with symmetric configuration for a thickness of 3mm were taken for free vibration analysis of beams. The fibre reinforcement was E-glass fibre and the matrix was epoxy resin along with a hardener. Filler materials used for investigations were calcium carbonate ($CaCO_3$), Nano clay, and Silicon Carbide (SiC). The specimen details are presented in Table **1** and their mechanical properties are presented in Table **2**.

SUBJECT INDEX

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