WIRELESS END TO END IMAGE TRANSMISSION SYSTEM USING LI-FI TECHNOLOGY

A PROJECT REPORT

Submitted by

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

The first and most important objective of this project is to convey the image through the utilization of a light-emitting diode (LED). The innovative technique known as visible light communication (VLC) holds enormous promise for the implementation of high-speed, large-capacity, short-range wireless data transmission. It is gaining popularity on account of the growing use of solid-state lighting systems. Additionally, LED lights change frequency at a rate that is substantially faster than what the human eye is able to perceive. This is in addition to the fact that radio waves have a higher repetition rate than LED lights, which results in significantly greater speed than Wi-Fi. This work suggests a real-time image broadcast system prototype. Light-emitting diode (LED) lights are used in the prototype since they are widely available and reasonably priced. The scope of the work encompasses the possibility of making information and communication accessible through the utilization of LED bulbs in a manner that may be implemented in a variety of situations, such as homes, offices, organizations, and corporations. If the LED sources are positioned correctly and concentration effects are increased, it is feasible to obtain a real-time image with a maximum distance of two feet, according to the testing results. In addition to being made to last, the LI-FI (Light Fidelity) light source features a broad variety of digital settings that can be adjusted, and it is simple to operate as a result of its efficient design.

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LIST OF ABBREVIATIONS

Li-Fi	-	Light Fidelity
LED	-	Light Emitting Diode
SMD	-	Surface Mount Device
OWC	-	Optical Wireless Communication
VCSEL	-	Vertical Cavity Surface Emitting Laser
CCR	-	Corner-Cube Retroreflector
ODTx	-	Omni Directional Transmitter
QoS	-	Quality of Service
IoT	-	Internet of Things
ANN	-	Artificial Neural Network
HLWNet	-	Hybrid Li-Fi & Wi Fi Network
UART	-	Universal Asynchronous Receiver/ Transmitter
DTE	-	Data Terminal Equipment

CHAPTER I

INTRODUCTION

1.1 PROJECT OVERVIEW

In the pursuit of elevating wireless communication systems, our project focuses on the innovative realm of Li-Fi, or Light Fidelity. Li-Fi represents a paradigm shift by harnessing light waves as the carriers for data transmission, offering an alternative to the conventional use of radio frequencies in technologies such as Wi-Fi. This project not only explores the fundamentals of Li-Fi but also delves into its potential applications, advantages, and the challenges it addresses in the domain of wireless communication.

Li-Fi holds the promise of revolutionizing how we transmit and receive data wirelessly. Unlike Wi-Fi, which relies on radio waves, Li-Fi utilizes the visible light spectrum, presenting several notable advantages. One significant benefit is its applicability in sensitive environments, such as aircraft, where traditional radio-based communication systems may cause interference. The inability of light waves to penetrate solid obstacles like walls becomes a unique advantage, enhancing the security and privacy aspects of Li-Fi communication within confined spaces.

At the heart of Li-Fi technology lies the ingenious use of Light Emitting Diodes (LEDs). LED light bulbs, conventionally utilized for illumination through a constant current, can be repurposed as high-speed data transmitters by modulating the optical output. This project explores the intricacies of this process, aiming to understand the optimal conditions for achieving rapid and reliable data transmission. The integration of existing LED infrastructure for Li-Fi implementation showcases practicality and cost-effectiveness of this technology, making it accessible for widespread adoption.

The operational principle of Li-Fi is elegantly simple yet highly effective. By exploiting the rapid on-off switching capability of LEDs, data can be encoded through variations in light intensity. When the LED is illuminated, it signifies the transmission of a digital 1, and when it is off, it denotes the transmission of a 0. The ability to switch LEDs on and off at extremely high speeds provides a fertile ground for exploring novel communication approaches. A key aspect of this project involves developing a controller that can efficiently encode data into LEDs, serving as the central intelligence orchestrating the modulation of light signals.

The versatility of Li-Fi technology extends beyond its simplicity. The project investigates the potential for further enhancements, such as optimizing modulation techniques to increase data transfer rates and extending the range of Li-Fi applications. The adaptability of Li-Fi for use in diverse industries becomes apparent, with possibilities ranging from aviation and healthcare to defense and beyond. As the technology continues to evolve, the project aims to contribute valuable insights into the ongoing development of Li-Fi communication systems.

Moreover, this project acknowledges the broader implications of Li-Fi technology in addressing the growing demand for high-speed, secure, and reliable wireless communication. The convergence of lighting and communication not only offers a unique solution but also opens up avenues for innovation in various sectors. By seamlessly integrating Li-Fi into existing infrastructures, our project envisions a future where wireless communication is not only efficient and fast but also conducive to privacy and security, thereby shaping the landscape of next-generation communication systems. Through meticulous research, experimentation, and analysis, this project aims to be at the forefront of advancing Li-Fi technology, unlocking its full potential for the benefit of society.

1.2 CURRENT SCENARIO

As we delve into the current scenario of our Li-Fi project, it is imperative to comprehend the existing landscape of wireless communication technologies and the unique position that Li-Fi occupies within this dynamic domain. The exploration of Li-Fi's current state encompasses the technological advancements, challenges encountered, and the potential applications that make it an exciting frontier for innovation.

In the realm of wireless communication, Wi-Fi has long been the dominant player, relying on radio frequencies to transmit data seamlessly across various environments. However, the increasing demand for faster, more secure, and efficient communication has spurred the exploration of alternative technologies, leading to the rise of Li-Fi. The current scenario witnesses a burgeoning interest in Li-Fi as a viable and groundbreaking solution that leverages visible light for data transmission.

One of the notable strengths of Li-Fi lies in its versatility, allowing for implementation in diverse settings. The project, at its core, aims to harness this versatility by using commercially available LED light bulbs as downlink transmitters. This not only capitalizes on the ubiquity of LEDs in everyday lighting applications but also underscores the cost-effectiveness of adapting existing infrastructure for Li-Fi purposes. The integration of Li-Fi into commonplace lighting systems is a pivotal aspect of the current scenario, as it highlights the potential for widespread adoption without the need for extensive overhauls.

The current state of Li-Fi technology also presents unique advantages in sensitive environments, such as aircraft, where traditional radio-based communication systems may pose challenges. The inability of light waves to penetrate solid obstacles, while considered a limitation in some scenarios, becomes a distinct advantage in confined spaces where data security and interference-free communication are paramount. This characteristic positions Li-Fi as a compelling solution for specific applications, contributing to its growing recognition and adoption in specialized sectors.

At the heart of the Li-Fi paradigm is the efficient modulation of light output from LEDs. The project focuses on the intricacies of this process, aiming to optimize the rate at which LEDs flicker to achieve maximum data transfer rates. This involves the development of a controller that plays a pivotal role in encoding data into LEDs, acting as the central intelligence orchestrating the modulation of light signals. The current scenario involves meticulous experimentation to understand the nuances of this modulation process, ensuring reliable and high-speed data transmission.

Despite its promise, Li-Fi is not without challenges. One significant limitation is the inability of light waves to penetrate walls, restricting its range and applicability in certain scenarios. However, ongoing research within the project seeks to address this limitation by exploring innovative layouts of LED sources and concentration effects to extend the maximum transmission distance.

As the project advances, the current scenario unfolds with experimental results showcasing the feasibility of achieving real-time image transmission at a maximum distance of 2 feet. These results are crucial in validating the practicality of Li-Fi implementation and provide a foundation for further optimization and enhancements.

In conclusion, the current scenario in our Li-Fi project marks a juncture where the technology stands on the precipice of transformation. From the integration of Li-Fi into existing lighting infrastructure to addressing challenges and maximizing its advantages, the project navigates the intricacies of this cutting-edge communication technology. The landscape is dynamic, filled with opportunities for innovation and refinement as we pave the way for a future where Li-Fi seamlessly integrates into our daily lives, transforming the way we perceive and experience wireless communication.

1.3 OBJECTIVE

The overarching objective of our project is to pioneer advancements in wireless communication technology through the exploration and implementation of Li-Fi (Light Fidelity). At the core of our endeavor lies the ambition to harness the potential of visible light waves for high-speed, secure, and efficient data transmission. Our project aims to break new ground by seamlessly integrating commercially available LED light bulbs, typically utilized for illumination, into a sophisticated Li-Fi communication system. This integration serves as a testament to the versatility and accessibility of Li-Fi technology, leveraging existing infrastructure to propel the evolution of communication systems.

One pivotal facet of our objective is to address the increasing demand for faster and more reliable wireless communication. The ubiquitous nature of Wi-Fi has been foundational in connecting the world, yet the limitations in speed and potential interference call for innovative alternatives. Li-Fi presents itself as a compelling solution, capitalizing on the inherent advantages of light waves to transmit data at unprecedented speeds, far surpassing the capabilities of traditional radio frequency-based systems. By achieving this objective, we aspire to contribute to the evolution of communication technologies and pave the way for a future where Li-Fi becomes an integral component of our interconnected world

Additionally, our project seeks to capitalize on the unique attributes of Li-Fi to navigate sensitive environments with precision and efficiency. The aviation industry, for instance, stands to benefit from the interference-free nature of Li-Fi in aircraft cabins. The objective is to showcase how Li-Fi can revolutionize communication in confined spaces, where traditional radio frequencies might pose challenges. By unraveling the potential of Li-Fi in such specialized settings, we aim to establish its credibility and foster adoption in sectors with distinct communication requirements.

Furthermore, our project sets out to overcome challenges associated with Li-Fi, particularly its limitation in penetrating solid obstacles like walls. Through meticulous experimentation and optimization of LED layouts, our objective is to extend the transmission range and enhance the practicality of Li-Fi for real-world applications. We aspire to develop a comprehensive understanding of the factors influencing Li-Fi's performance, leading to advancements that address existing limitations and position Li-Fi as a versatile and reliable communication solution.

Another crucial objective is the development of a controller that acts as the brain of the Li-Fi system, efficiently encoding data into LEDs and orchestrating the modulation of light signals. This controller plays a pivotal role in translating the simplicity of the on-off switching of LEDs into a sophisticated language of data transmission. The objective is to design a controller that is not only robust and efficient but also adaptable to diverse applications, contributing to the versatility of Li-Fi technology.

In conclusion, the objectives of our project are multifaceted, ranging from advancing the speed and reliability of wireless communication to addressing challenges associated with Li-Fi technology. By seamlessly integrating Li-Fi into existing infrastructure, navigating specialized environments, optimizing LED layouts, and developing an intelligent controller, we aim to contribute significantly to the evolution of communication systems. Our overarching goal is to position Li-Fi as a transformative force, offering a glimpse into a future where visible light becomes the medium for efficient, secure, and high-speed wireless data transmission.

1.4 SIGNIFICANCE

The significance of our project exploring Li-Fi technology extends far beyond the realms of innovation and technological curiosity. It heralds a transformative era in wireless communication, promising to reshape the way we connect, communicate, and interact with our increasingly digital and interconnected world. The multifaceted significance of this endeavor encompasses technological advancements, societal implications, and the potential to address current communication challenges.

At a technological level, the adoption and refinement of Li-Fi represent a leap forward in the evolution of wireless communication systems. The traditional reliance on radio frequencies, epitomized by Wi-Fi, has faced limitations in terms of speed, security, and efficiency. Li-Fi, by leveraging visible light waves, overcomes these limitations and offers unprecedented data transfer rates. The project's significance lies in its potential to unlock a new era of communication where speed, reliability, and efficiency are no longer compromise points but integral features of the system.

Moreover, the significance of our exploration of Li-Fi technology becomes pronounced when considering its potential applications in sensitive environments.

Traditional wireless communication systems, especially those relying on radio frequencies, often encounter challenges in specific settings such as aircraft cabins, where interference must be minimized. Li-Fi, with its unique advantage of not penetrating solid obstacles like walls, emerges as a game-changer in such scenarios. The project's significance extends to showcasing how Li-Fi can revolutionize communication in confined spaces, where traditional systems may fall short, thereby contributing to enhanced safety and efficiency in critical industries.

The project also holds societal significance by addressing the growing demand for faster and more secure data transmission. As our reliance on digital communication continues to soar, there is an inherent need for technologies that can keep pace with the data-intensive demands of modern life. Li-Fi's potential to transmit data at remarkable speeds, exceeding those of traditional Wi-Fi, positions it as a key player in meeting the escalating requirements of a data-centric society. The significance lies in the project's contribution to shaping a future where seamless and high-speed communication is not a luxury but a fundamental expectation.

Furthermore, the project's significance extends to its environmental implications. By repurposing commercially available LED light bulbs for communication purposes, the endeavor aligns with sustainability goals. The dual use of LEDs for both illumination and data transmission showcases an eco-friendly approach, reducing the need for additional infrastructure and minimizing electronic waste. This alignment with sustainability objectives underscores the broader societal impact of the project, contributing to a more environmentally conscious technology landscape.

Addressing the limitations of Li-Fi, such as its range restrictions due to the inability of light waves to penetrate obstacles, adds another layer of significance to the project. The endeavor to optimize LED layouts and improve transmission distance enhances the practicality and adaptability of Li-Fi for a broader range of applications. Overcoming these challenges is not only a technical feat but also a testament to the project's commitment to making Li-Fi a robust and viable solution for diverse real-world scenarios.

In conclusion, the significance of our project exploring Li-Fi technology reverberates across technological, societal, and environmental dimensions. It propels us into a future where wireless communication is not just faster but also more versatile, secure, and sustainable. By pioneering advancements in Li-Fi, the project aspires to contribute to a paradigm shift in how we perceive and engage with wireless communication, underscoring the transformative power of visible light in shaping the next generation of connectivity.

1.5 INNOVATION

In the expansive landscape of technological progress, innovation stands as the driving force propelling societies towards new horizons, and our project exploring Li-Fi technology is a testament to this spirit of innovation. The endeavor to harness visible light waves for wireless communication not only represents a departure from conventional norms but also heralds a paradigm shift in how we perceive and engage with connectivity. The innovation embedded in this project spans technological advancements, novel applications, and the evolution of existing infrastructures.

Technological innovation is at the forefront of our exploration of Li-Fi. Traditional wireless communication systems, epitomized by Wi-Fi, have long relied on radio frequencies for data transmission. The innovation inherent in Li-Fi lies in its departure from this established norm, opting instead for visible light waves. This shift not only introduces a new dimension to data transmission but also addresses inherent limitations of traditional systems. The rapid modulation of LED light sources for data encoding represents a groundbreaking technological leap, enabling data transfer at speeds that were once deemed implausible. This innovation in data transfer mechanisms opens up avenues for faster, more secure, and efficient communication systems.

The project's innovation also extends to its strategic use of existing infrastructure. Commercially available LED light bulbs, typically employed for illumination, are repurposed as downlink transmitters in our Li-Fi system. This creative reuse of ubiquitous technology showcases an innovative approach, minimizing the need for additional infrastructure while maximizing the potential for widespread adoption. This dual application of LEDs not only reduces electronic waste but also aligns with sustainability goals, adding an environmentally conscious dimension to the project's innovative endeavors.

Furthermore, the project introduces an innovative perspective on communication in confined and sensitive environments. The aviation industry, characterized by the need for interference-free communication in aircraft cabins, stands to benefit significantly from the Li-Fi technology's unique attributes. By not penetrating solid obstacles, Li-Fi introduces a novel solution for communication challenges in enclosed spaces, showcasing the project's capacity to address real-world scenarios through innovation. This application of Li-Fi in specialized environments represents a forward-thinking approach to technology implementation.

The project's innovation is also evident in its approach to overcoming challenges associated with Li-Fi technology. The limitation of light waves in penetrating obstacles, like walls, is a recognized constraint. However, the innovation lies in the meticulous experimentation and optimization of LED layouts to extend the transmission range. The pursuit of solutions to overcome these challenges not only showcases the project's commitment to innovation but also positions Li-Fi as a versatile and adaptive technology capable of addressing diverse communication needs.

Additionally, the development of a controller that efficiently encodes data into LEDs and orchestrates the modulation of light signals represents an innovative leap in Li-Fi technology. This intelligent controller serves as the central nervous system of the Li-Fi system, translating complex data into a language of light. The innovative design and functionality of this controller contribute to the project's overall goal of making Li-Fi accessible and adaptable to various applications.

In conclusion, the innovation embedded in our project exploring Li-Fi technology is multifaceted, spanning technological breakthroughs, sustainable applications, and problem-solving approaches. By challenging established norms and embracing a vision for the future where visible light serves as the medium for communication, the project stands as a beacon of innovation in the dynamic landscape of wireless connectivity. This spirit of innovation not only propels the project forward but also holds the potential to reshape the trajectory of wireless communication systems, ushering in a new era of connectivity and technological possibilities.

1.6 MEASUREMENT

The measurement of our Li-Fi project encompasses a comprehensive evaluation of various key metrics, each designed to gauge the effectiveness, efficiency, and practicality of the implemented technology. From the technical aspects of data transfer rates and signal strength to the real-world applicability of Li-Fi in different environments, the measurement parameters aim to provide a holistic understanding of the project's impact and success.

One crucial metric for measurement is the data transfer rate achieved through the Li-Fi system. This involves assessing the speed at which digital information is transmitted using visible light waves. The goal is to quantify the efficiency of the Li-Fi technology in comparison to traditional wireless communication systems, such as Wi-Fi. Higher data transfer rates signify a successful implementation and highlight the potential for Li-Fi to revolutionize communication by offering faster and more reliable data transmission.

Signal strength is another pivotal aspect of measurement. This metric involves assessing the robustness and stability of the Li-Fi signal across different distances. By conducting systematic experiments at varying distances, we can determine the range over which the Li-Fi system maintains a strong and consistent signal. Understanding signal strength is essential for optimizing the layout of LED sources and ensuring that the technology is viable for practical applications in diverse settings.

The measurement also extends to the adaptability and reliability of Li-Fi in overcoming challenges associated with obstacles. This includes evaluating the effectiveness of the optimized LED layouts in extending the transmission distance and addressing limitations related to the inability of light waves to penetrate walls. The project's success is measured not only in its ability to recognize these challenges but also in its capacity to develop practical solutions that enhance the versatility and applicability of Li-Fi in real-world scenarios.

In addition, the measurement encompasses an assessment of the power efficiency and sustainability of the Li-Fi system. This involves evaluating the energy consumption of the technology and comparing it to traditional communication systems. A successful Li-Fi implementation should demonstrate not only superior data transfer rates but also an eco-friendly approach by repurposing existing LED infrastructure for communication purposes.

Real-world applicability is a critical dimension of measurement, involving the evaluation of Li-Fi in specialized environments. For instance, in the aviation industry, the project measures the interference-free communication within aircraft cabins, showcasing the adaptability of Li-Fi in addressing specific challenges unique to such settings. The success of Li-Fi in these environments is gauged by its ability to provide reliable and secure communication without compromising safety or performance.

Furthermore, the user experience plays a significant role in measurement. This involves assessing the ease of use, accessibility, and user-friendliness of the Li-Fi system. The development and functionality of the controller, which encodes data into LEDs and modulates light signals, contribute to the overall user experience. A successful Li-Fi system should not only be technologically advanced but also practical and user-friendly for widespread adoption.

In conclusion, the measurement of our Li-Fi project is a multifaceted process that encompasses technical parameters, real-world applicability, sustainability, and user experience. This systematic measurement approach is essential for validating the project's objectives, identifying areas for improvement, and ultimately contributing to the advancement of Li-Fi in the ever-evolving landscape of wireless communication systems.

1.7 APPLICATIONS

The applications of our Li-Fi project are vast and encompass a diverse array of industries and environments, showcasing the versatility and transformative potential of visible light communication. By leveraging commercially available LED light bulbs for data transmission, our project introduces innovative solutions to various sectors, addressing specific challenges and ushering in new possibilities for connectivity.

1. Aviation Industry:

Li-Fi's interference-free communication capabilities make it particularly suitable for the aviation industry, where traditional radio-based systems may encounter challenges. The project envisions Li-Fi as a reliable and secure means of communication within aircraft cabins, ensuring efficient data transfer without compromising safety or performance.

2. Healthcare Environments:

Li-Fi holds significant promise in healthcare settings, where the need for reliable and secure communication is paramount. Applications include data transmission in hospital wards, surgical theaters, and medical laboratories. The interference-free nature of Li-Fi is especially beneficial in environments where radio frequencies may interfere with sensitive medical equipment.

3. Industrial Automation:

In industrial settings, where rapid and secure data transmission is essential for automation processes, Li-Fi can find applications. The project explores how Li-Fi can be utilized in smart factories and industrial automation, providing a wireless communication solution that is both efficient and immune to electromagnetic interference.

4. Smart Homes and Offices:

Li-Fi can revolutionize communication in smart homes and offices, offering high-speed and reliable connectivity without the potential interference associated with traditional Wi-Fi. From smart lighting control to seamless data transfer in connected environments, Li-Fi has the potential to enhance the efficiency and connectivity of smart homes and offices.

5. Retail Environments:

Li-Fi can be employed in retail environments to enhance customer experiences. For instance, it can facilitate location-based services, enabling customers to receive real-time information or promotions on their smartphones as they navigate through a store. The high-speed data transmission capability of Li-Fi contributes to a more responsive and interactive retail environment.

6. Educational Institutions:

In educational settings, Li-Fi can be utilized for efficient communication and data transfer in classrooms and lecture halls. The technology's ability to transmit data at high speeds can enhance interactive learning experiences, facilitate quick sharing of educational content, and support emerging technologies in education.

7. Defense and Security:

Li-Fi's interference-free and secure communication characteristics make it relevant in defense and security applications. The project explores the potential for Li-Fi in secure communication channels, ensuring confidential data transmission without the risk of radio frequency interception.

8. Transportation Systems:

Li-Fi can be integrated into various transportation systems, contributing to enhanced connectivity and communication between vehicles, transit hubs, and infrastructure. In applications such as connected cars and smart transportation systems, Li-Fi offers a promising solution for high-speed data exchange.

CHAPTER II
LITERATURE SURVEY

2.1 INTRODUCTION

The existing Wi-Fi-based wireless communication system faces several limitations. One major issue is interference, which occurs in crowded areas due to a limited number of frequency channels, resulting in reduced speeds and degraded performance. Additionally, susceptibility to electromagnetic interference from various devices poses challenges. Security concerns arise as Wi-Fi signals extend beyond physical boundaries, potentially allowing unauthorized access. Specialized environments like aircraft cabins require interference-free communication, and the limited range of Wi-Fi signals is problematic in large spaces or areas with obstacles. Exploring alternatives such as Li-Fi, which uses visible light waves, could address these challenges and revolutionize wireless communication.

2.2 EXISTING SYSTEM

2.2.1 26Gbit/s LiFi System With Laser-Based White Light Transmitter

Wedemonstrate a high-speed light fidelity (LiFi) communication system deploying ultra-high brightness laser-based white light illumination sources in a surface mount device (SMD) packaging platform. The LiFi transmitter SMD source provides 450 lumens of white light output with a brightness of 1000 cd/mm ^{2} in a dual wavelength configuration comprising blue and infrared (IR) emitting laser diodes within the SMD. First, we present high-speed data transmission beyond 25 Gbit/s over a 3 meter channel distance with the combined data rates from the blue and IR lasers in the single SMD. Next, we present a 2.8 Gbit/s data rate with the dual wavelength laser SMD light source using a side-emissive fiber as the transmitter.

This work proves the viability of LiFi systems deploying laser-based white light sources operating at very high data rates with the visible light and communication signal delivered in conventional free-space transmission architectures along with novel configurations using side-emitting fibers.

2.2.2 A VCSEL Array Transmission System With Novel Beam Activation Mechanisms

Optical wireless communication (OWC) is considered to be a promising technology which will alleviate traffic burden caused by the increasing number of mobile devices. In this study, a novel vertical-cavity surface-emitting laser (VCSEL) array is proposed for indoor OWC systems. To activate the best beam for a mobile user, two beam activation methods are proposed for the system. The method based on a corner-cube retroreflector (CCR) provides very low latency and allows real-time activation for high-speed users. The other method uses the omnidirectional transmitter (ODTx). The ODTx can serve the purpose of uplink transmission and beam activation simultaneously. Moreover, systems with ODTx are very robust to the random orientation of a user equipment (UE). System level analyses are carried out for the proposed VCSEL array system. For a single user scenario, the probability density function (PDF) of the signal-to-noise ratio (SNR) for the central beam of the VCSEL array system can be approximated as a uniform distribution. In addition, the average data rate of the central beam and its upper bound are given analytically and verified by Monte-Carlo simulations. For a multi-user scenario, an analytical upper bound for the average data rate is given.

2.2.3 Energy Efficient QoS-Based Access Point Selection in Hybrid WiFi and LiFi IoT Networks

Ensuring Quality of Service (QoS) in next-generation networks would be challenging because of the expected manifolds increase in network traffic volume and the massive number of connected Internet of Things (IoT) devices. The increased resources on end-devices have made it possible to make decisions on the client-side for Access Point (AP) selection. On the other hand, due to power constraints on the client-side, energy efficiency is also essential. This paper presents a client-side energy-efficient AP selection approach for QoS provisioning in hybrid Wireless Fidelity (WiFi) and Light Fidelity (LiFi) networks. Compared to conventional WiFi and LiFi approaches, the proposed technique outperforms them in energy efficiency at any data rate and in QoS provisioning at data rates higher than 10 Mbps for a network of 50 nodes. It is also shown that adapting the uplink transmission power improves the IoT node's energy efficiency by transmitting at minimal transmission power required to satisfy the throughput QoS constraint. This paper's contributions include the proposed algorithm, complexity and convergence analyses of the algorithm, simulation-based evaluation, and analysis of the uplink transmission power adaption. The results show that the presented technique could be integrated into next-generation networks for QoS provisioning and improving energy efficiency.

2.2.4 Terabit Optical Wireless-Fiber Communication With Kramer-Kronig Receiver

An optical communication link is proposed for high speed point-to-point data transmission. The link incorporates both fiber and optical wireless technologies. Kramer-Kronig coherent detection is used due to its component and implementation simplicity. Spatial multiplexing, via a multi-core fiber followed by a wireless link, and wavelength division multiplexing allow the efficient exploitation of all available degrees of freedom. The link signal-to-noise ratio is estimated when all possible noise sources are taken into account. The impact of link loss and optical amplifier placement on the achievable SNR are studied theoretically. Finally, it is shown that over 1 Tb/s is achievable per wavelength with a 4-core fiber and a simple optical wireless alignment system. An important application of this design would be backhaul and intra-data center links.

2.2.5 An Artificial Neural Network-Based Handover Scheme for Hybrid LiFi Networks

Combining the ultra-high user throughput of the light fidelity (LiFi) and the ubiquitous coverage of wireless fidelity (WiFi), the hybrid LiFi and WiFi network (HLWNet) demonstrates unparalleled advantages in indoor wireless data transmission. Due to the line-of-sight propagation nature of the optical signal, the handover decision-making problem in HLWNets, however, becomes more critical and challenging than that in previous heterogeneous networks. In this paper, the handover decision-making problem in the HLWNet is regarded as a binary classification problem, and an artificial neural network (ANN)-based handover scheme is proposed. The complete handover scheme consists of two sets of ANNs that use the information about channel quality, user movement, and device orientation as input features to make handover decisions. After being trained with the labeled datasets that are generated with a novel approach, the ANN-based handover scheme is able to achieve over 95% handover accuracy. The proposed scheme is then compared with benchmarks under an indoor simulation scenario. The simulation results show that the proposed approach can significantly increase user throughput by 20.5 – 46.7% and reduce handover rate by around 59.5 – 78.2% as compared with the benchmarks; in the meanwhile, it maintains a great robustness performance against user mobility and channel variation.

2.3 SUMMARY

Our project delves into Li-Fi technology, utilizing visible light waves for wireless communication to surpass Wi-Fi limitations. By repurposing LED bulbs, we create a real-time image broadcast system, addressing efficiency and environmental concerns. Li-Fi achieves higher data transfer rates, spanning sectors like aviation, healthcare, and industrial automation. Metrics include data rates, signal strength, adaptability, and sustainability, emphasizing real-world applicability.Wi-Fi's drawbacks motivate Li-Fi exploration, which pioneers efficient, secure, and high-speed wireless data transmission.

CHAPTER III

PROPOSED SYSTEM

WIRELESS END TO END IMAGE TRANSMISSION SYSTEM USING LI-FI TECHNOLOGY

3.1 INTRODUCTION

The proposed Li-Fi system introduces a groundbreaking real-time image broadcast system using commercially available LED light bulbs for wireless data transmission. By leveraging visible light waves, it offers an alternative to traditional Wi-Fi systems, aiming to revolutionize wireless communication.

At its core, the system repurposes LED bulbs as downlink transmitters, transforming lighting infrastructure into a communication medium while promoting sustainability by minimizing electronic waste.

Innovation lies in rapidly modulating LED light sources for high-speed data transfer. This approach optimizes efficiency and reliability, addressing limitations of existing Wi-Fi systems, particularly in specialized environments like aircraft cabins.

Measurement metrics encompass data transfer rates, signal strength, adaptability, power efficiency, and user experience, ensuring comprehensive evaluation. The system holds potential for diverse applications, positioning Li-Fi as a transformative force in wireless communication.

3.2 PROPOSED METHOD

The proposed Li-Fi system represents a pioneering effort in utilizing LED light bulbs for wireless data transmission, aiming to redefine wireless communication by leveraging visible light waves. It introduces innovative methodologies for data transmission and integrates Li-Fi into everyday environments through existing LED infrastructure. Central to the system is the use of LED light bulbs as downlink transmitters in the Li-Fi network, repurposing them for high-speed data transmission through light intensity modulation. This dual functionality showcases Li-Fi's adaptability and aligns with sustainability goals by maximizing the utility of LED technology.

The system's methodology focuses on efficiently modulating LED light sources for rapid and reliable data transfer. Through meticulous experimentation, the flickering rate of LEDs is optimized to ensure efficient data transmission. This dynamic modulation forms the core of Li-Fi's groundbreaking approach to wireless communication. A key objective is to address limitations of existing wireless communication, particularly Wi-Fi, by offering an interference-free alternative suitable for specialized environments like aircraft cabins. Li-Fi's advantages include high-speed, secure, and reliable communication.

The methodology includes measuring parameters such as data transfer rates, signal strength, and user experience to evaluate Li-Fi's performance comprehensively

The proposed system holds promise for various sectors, including smart homes, industrial automation, and healthcare. By refining the methodology, the project aims to contribute to Li-Fi's evolution as a viable solution for high-speed, secure, and environmentally conscious wireless communication, shaping a future powered by visible light waves.

3.2.1 OBJECTIVE

The objectives of the proposed work are rooted in the ambitious pursuit of advancing wireless communication technology through the innovative implementation of Li-Fi (Light Fidelity). The project sets out to achieve a multifaceted range of goals, each contributing to the overarching vision of leveraging visible light waves for high-speed, secure, and efficient data transmission.

3.2.2.BLOCK DIAGRAM

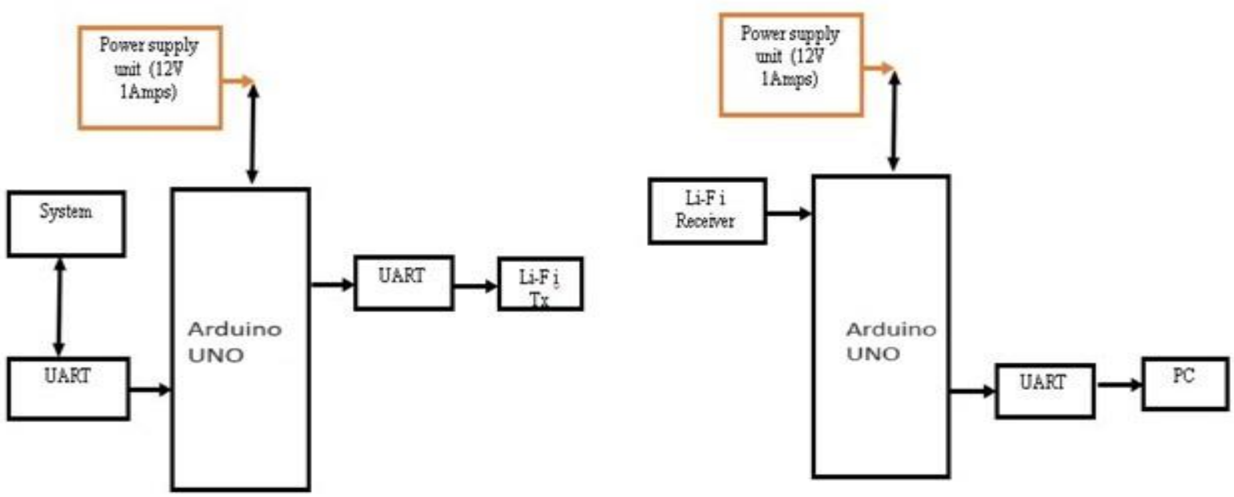


Fig: 3.2.1 Block diagram of Li Fi

3.2.3 HARDWARE AND SOFTWARE REQUIREMENTS

Hardware:

1) Lifi transmitter
2) Lifi receiver
3) Power supply unit
4) Power supply adapter
5) Uart to ttl
6) System
7) Lifi amplifier
8) Arduino UNO

Software:

1. Embedded C
2. Arduino IDE

3.2.4 METHODOLOGY

The methodology for the proposed work unfolds in a systematic progression, commencing with a comprehensive literature review to establish a robust foundation in the principles of Li-Fi technology. This initial phase involves an in-depth examination of existing research, academic papers, and patents, offering valuable insights into modulation techniques, challenges, and real-world applications of Li-Fi. Subsequently, the focus shifts to a theoretical understanding of Li-Fi principles, laying the groundwork for practical implementation. The project then ventures into the repurposing of commercially available LED light bulbs, exploring methods to adapt their dual functionality for both illumination and high-speed data transmission.

A pivotal aspect of the methodology involves the experimental optimization of data transfer rates, wherein the flickering rates of LEDs are systematically varied to identify the most efficient modulation scheme, surpassing traditional wireless communication systems like Wi-Fi.

Addressing interference and security concerns is a critical facet, and the methodology incorporates experiments to validate Li-Fi's inherent resistance to interference while implementing robust security measures. The project extends its scope to showcase the applicability of Li-Fi in specialized environments, particularly the aviation industry, through real-world experiments within aircraft cabins. Overcoming the limitation of Li-Fi's range is systematically approached by experimenting with different LED layouts to enhance transmission range, thereby increasing the adaptability of Li-Fi for diverse scenarios. A key development in the methodology involves the design and construction of an intelligent controller, serving as the central orchestrator for the modulation of light signals. This controller plays a pivotal role in encoding data into LEDs, contributing to the adaptability and versatility of Li-Fi technology. The final stage embraces a comprehensive measurement and evaluation process, systematically assessing key metrics such as data transfer rates, signal strength, power efficiency, and user experience. This meticulous evaluation ensures that the Li-Fi system not only meets technical benchmarks but also aligns seamlessly with practical requirements, paving the way for a future where visible light stands as a powerful medium for efficient and secure wireless communication.

LI-FI

Li-Fi technology is a ground-breaking light-based communication technology, which makes use of light waves instead of radio technology to deliver data. Using the visible light spectrum, Li-Fi technology can transmit data and unlock capacity which is 10,000 times greater than that available within the radio spectrum. The visible light spectrum is plentiful, free and unlicensed, mitigating the radio frequency spectrum crunch effect.

FUTURE INTERNET

Fig 3.2.2 Li-Fi in Future

Li-Fi technology will in future enable faster, more reliable internet connections, even when the demand for data usage has outgrown the available supply from existing technologies such as 4G, LTE and Wi-Fi. It will not replace these technologies, but will work seamlessly alongside them.Using light to deliver wireless internet will also allow connectivity in environments that do not currently readily support Wi-Fi, such as aircraft cabins, hospitals and hazardous environments.Light is already used for data transmission in fibre-optic cables and for point to point links, but Li-Fi is a special and novel combination of technologies that allow it to be universally adopted for mobile ultra high speed internet communications.

HOW **IT'S WORKS:**

- Li-Fi and Wi-Fi are quite similar as both transmit data electromagnetically. However, Wi-Fi uses radio waves while Li-Fi runs on visible light.
- A VLC light source could comprise of a fluorescent or light emitting diode (LED) bulb. Since a robust Li-Fi system requires extremely high rates of light output, LED bulbs are most ideal for implementing Li-Fi. LED is a semiconductor light source, which implies that LED light bulbs can amplify light intensity and switch rapidly. Therefore, LED cells can modulate thousands of signals without the human eye ever noticing.
- In turn, the changes in light intensity from the LED light source are interpreted and converted as electrical current by the receiving photodiode device. Once the electronic signal is demodulated, it is converted into a continuous stream of binary data comprising of audio, video, web, and application information to be consumed by any Internet-enabled device.
- For example, data is fed into an LED light bulb , it then sends data at rapid speeds to the photo-detector.
- The tiny changes in the rapid dimming of LED bulbs are then converted by the 'receiver' into electrical signal.
- The signal is then converted back into a binary data stream that we would recognise as web, video and audio applications that run on internet enables devices.
- Li-Fi is a Visible Light Communications (VLC) system for data transmission. A simple VLC system has two qualifying components:
    - One device with a photodiode able to receive light signals
    - A light source equipped with a signal processing unit.

- There is ample room for growing innovation in Li-Fi technology. Like conventional broadband and Wi-Fi, Li-Fi can also function as a bidirectional communication system.
- By interchanging visible light and infrared light from a photo detector, a mobile device connected to that photo detector can send data back to the light source for uplink. Also, multicoloured RGB (Red/Green/Blue) LED's at retina size could be engineered to send and receive a wider range of signals than single-colored phosphor-coated white LED's.

FEATURES OF LI-FI:

- Cellular communication and Emi sensitive environments
- Augmented reality and Localised advertising
- Underwater communication and Safety environments

BENEFITS OF LIFI SYSTEM

- It transfers data very rapidly.
- It transfers data securely as it can be used in Line of Sight mode of optical signal.
- It does not pierce through the walls and hence it cannot be easily intruded by hackers.
- It uses much low power for transmission compare to other systems such as Wi-Fi.

ADVANTAGES OF LI FI TECHNOLOGY

- Li-Fi can solve problems related to the insufficiency of radio frequency bandwidth because this technology uses Visible light spectrum that has still not been greatly utilized.
- High data transmission rates of up to 10Gbps can be achieved.
- Since light cannot penetrate walls, it provides privacy and security that Wi-Fi cannot.
- Li-Fi has low implementation and maintenance costs.

APPLICATION OF LI FI TECHNOLOGY

- Airlines
- Smarter Power Plants
- Undersea application
- It Could Keep You Informed and Save Lives

ARDUINO UNO

Arduino Uno is a popular microcontroller board based on the ATmega328P chip. It features digital and analog input/output pins that can be programmed to interact with various electronic components. Arduino Uno is widely used for prototyping projects in the fields of electronics, robotics, and automation due to its simplicity, versatility, and extensive community support. It can be programmed using the Arduino Integrated Development Environment (IDE), which offers an easy-to-use interface for writing and uploading code. With its affordability and beginner-friendly design, Arduino Uno is an ideal choice for both hobbyists and professionals exploring the world of embedded systems and DIY electronics.

ARDUINO UNO HARDWARE SPECIFICATIONS

Fig 3.2.3 ARDUINO UNO BOARD

MICROCONTROLLER:

The main processing unit of the Arduino Uno is an Atmel ATmega328P microcontroller. It handles tasks such as running code, reading inputs, and controlling outputs.

USB INTERFACE:

Arduino Uno features a USB interface that allows for programming and communication with a computer. It uses a USB Type-B connector for connection to the host computer.

POWER SUPPLY:

The board can be powered through the USB connection from a computer or an external power source connected to the DC power jack. It also includes a voltage regulator that provides stable 5V and 3.3V power outputs.

DIGITAL INPUT/OUTPUT PINS:

Arduino Uno has a total of 14 digital input/output pins, marked as digital pins 0 to 13. These pins can be configured as either inputs or outputs for interfacing with external digital devices.

ANALOG INPUT PINS:

The board has six analog input pins, labeled A0 to A5, which can measure voltage levels between 0 and 5 volts.

PWM (PULSE WIDTH MODULATION) PINS:

Arduino Uno includes six PWM pins, which can generate analog-like output signals by varying the duty cycle of the waveform.

RESET BUTTON:

A reset button allows for restarting the microcontroller and re-running the uploaded sketch.

CRYSTAL OSCILLATOR:

The board includes a crystal oscillator (16 MHz) to provide clock pulses for the microcontroller, ensuring accurate timing for program execution.

LED INDICATOR:

There is an onboard LED connected to digital pin 13, which is commonly used for simple debugging purposes.

ICSP (IN-CIRCUIT SERIAL PROGRAMMING) HEADER:

This header allows for programming the microcontroller using an external programmer.

UART

The Universal Asynchronous Receiver/ Transmitter is a serial input & output port. That can be used to transfer the serial data in the form of text and it is useful for converting the debugging code.

STORAGE

One of the most important elements of any computer is the storage, from where the operating system is run and data stored. The Pi doesn’t have a hard disk drive – instead, it is equipped with a SD card reader.

SPECIFICATION

- Microcontroller: Atmel ATmega328P
- Operating Voltage: 5 volts
- Input Voltage (recommended): 7-12 volts
- Input Voltage (limits): 6-20 volts
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA
- EEPROM: 1 KB

- Clock Speed: 16 MHz
- USB Interface: ATmega16U2 (or CH340G on some clones)
- Dimensions: 68.6 mm × 53.4 mm
- Weight: 25 g

Fig 3.2.4 SD card reader

FEATURES OF ARDUINO UNO

- Microcontroller: Atmel ATmega328P
- Digital I/O Pins: 14 (6 PWM)
- Analog Input Pins: 6
- USB Interface for programming and communication
- Power options: USB or external power source
- Clock Speed: 16 MHz
- Onboard LED (connected to pin 13)
- Extensibility with shields and modules
- Open-source hardware and software
- Versatile for a wide range of projects.

APPLICATIONS OF ARDUINO UNO

The Arduino uno boards are used in many applications like

- Prototyping electronic projects
- Home automation
- Robotics
- IoT (Internet of Things) projects
- Sensor data logging
- Educational projects
- DIY electronics
- Wearable technology
- Environmental monitoring
- Interactive art installations

REGULATOR

Voltage regulator ICs are available with fixed or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current and overheating.The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and current.

1. Positive regulator

    1. input pin
    2. ground pin
    3. output pin

2. It regulates the positive voltage

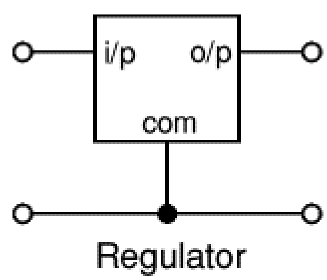
3. Negative regulator

4. Ground pin

5. Input pin

6. Output pin

It regulate the negative voltage.The regulated DC output is very smooth with no ripple. It is suitable for all electronic circuits.



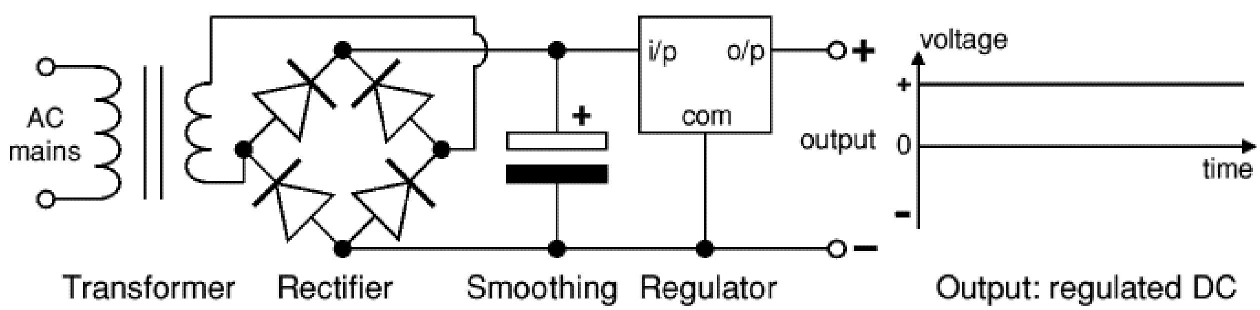


Fig 3.2.5 Functions of regulator

UART

The Universal Asynchronous Receiver/Transmitter (UART) controller is the key component of the serial communications subsystem of a computer. UART is also a common integrated feature in most microcontrollers. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes.

Serial transmission of digital information (bits) through a single wire or other medium is much more cost effective than parallel transmission through multiple wires. Communication can be “full duplex” (both send and receive at the same time) or “half duplex” (devices take turns transmitting and receiving).

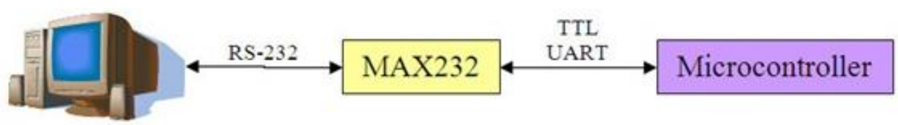


Fig 3.2.6 UART

A UART (Universal Asynchronous Receiver/Transmitter) is the microchip with programming that controls a computer's interface to its attached serial devices. Specifically, it provides the computer with the RS-232C Data Terminal Equipment (DTE) interface so that it can "talk" to and exchange data with modems and other serial devices. As part of this interface, the UART also:

- Converts the bytes it receives from the computer along parallel circuits into a single serial bit stream for outbound transmission
- On inbound transmission, converts the serial bit stream into the bytes that the computer handles

- Adds a parity bit (if it's been selected) on outbound transmissions and checks the parity of incoming bytes (if selected) and discards the parity bit
- Adds start and stop delineators on outbound and strips them from inbound transmissions
- Handles interrupt s from the keyboard and mouse (which are serial devices with specialport s)
- May handle other kinds of interrupt and device management that require coordinating the computer's speed of operation with device speeds.

THE ASYNCHRONOUS RECEIVING AND TRANSMITTING PROTOCOL

Asynchronous transmission allows data to be transmitted without the sender having to send a clock signal to the receiver. In this case, the sender and receiver must agree on timing parameters (Baud Rate) prior transmission and special bits are added to each word to synchronize the sending and receiving units. In asynchronous transmission, the sender sends a Start bit, 5 to 8 data bits (LSB first), an optional Parity bit, and then 1, 1.5 or 2 Stop bits.

When a word is passed to the UART for asynchronous transmission~~s~~, the Start bit is added at beginning of the word. The Start bit is used to inform the receiver that a word of data is about to be send, thereby forcing the clock in the receiver to be in sync with the clock in the transmitter. It is important to note that the frequency drift between these two clocks must not exceed 10%. In other words, both the transmitter and receiver must have identical baud rate.

After the Start bit, the individual bits of the word of data are sent, beginning with the Least Significant Bit (LSB). When data is fully transmitted, an optional parity bit is sent to the transmitter. This bit is usually used by receiver to perform simple error checking. Lastly, Stop bit will be sent to indicate the end of transmission.

When the receiver has received all of the bits in the data word, it may check for the Parity Bits (both sender and receiver must agree on whether a Parity Bit is to be used), If the Stop Bit does not appear when it is supposed to, the UART considers the entire word to be garbled and will report a Framing Error to the host processor when the data word is read.

THE PHYSICAL LAYER STANDARDS

There are actually quite a number of different standards that utilizes similar protocol. For instances, TTL level UART, RS-232, RS-422, RS-485 and etc. We will only discuss about TTL level UART and RS-232 in this article.

TTL level UART

Most microcontrollers with UART use TTL (Transistor-transistor Logic) level UART. It is the simplest form of UART. Both logic 1 and 0 are represented by 5V and 0V respectively.

Logic	Voltage
Low	0V
High	5V

Table 3.1 Voltage level for TTL level UART

The TTL level UART is commonly used in the communications between microcontrollers and ICs. Only 2 wires are required for the full duplex communications as illustrated in the picture below.

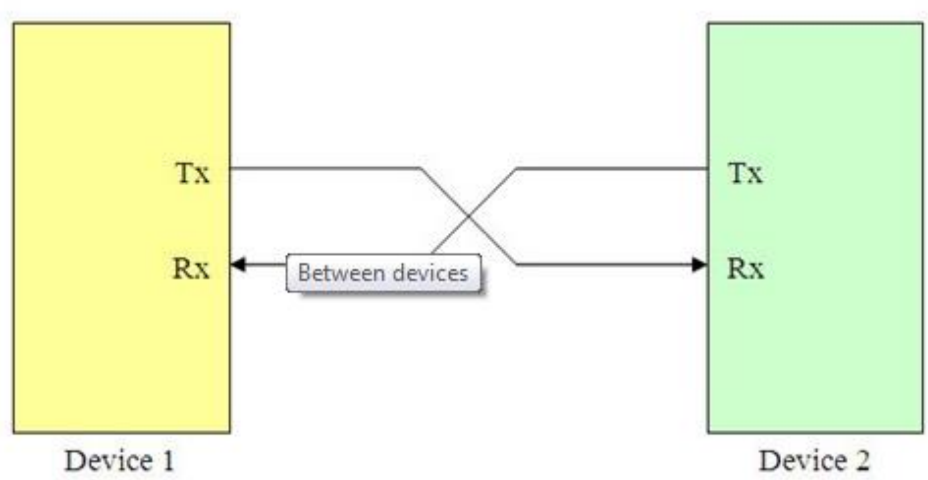


Fig 3.2.7 UART Communications

RS-232

RS-232 (Recommended Standard 232) is a standard for serial binary data signals connecting between a Data Terminal Equipment (DTE) and a Data Communication Equipment (DCE). It is commonly used in computer serial ports. One of the significant differences between TTL level UART and RS-232 is the voltage level. Valid signals in RS-232 are ±3 to – ±15V, and signals near 0V is not a valid RS-232 level.

Logic	Voltage
Low	+3 to +15V
High	-3 to -15V

Table 3.2 Voltage level for RS-232

Besides voltage level, the RS-232 also has a few extra pins specifically designed for the communication between PC and modem. The pinots of the DB-9 and their functions are shown below.

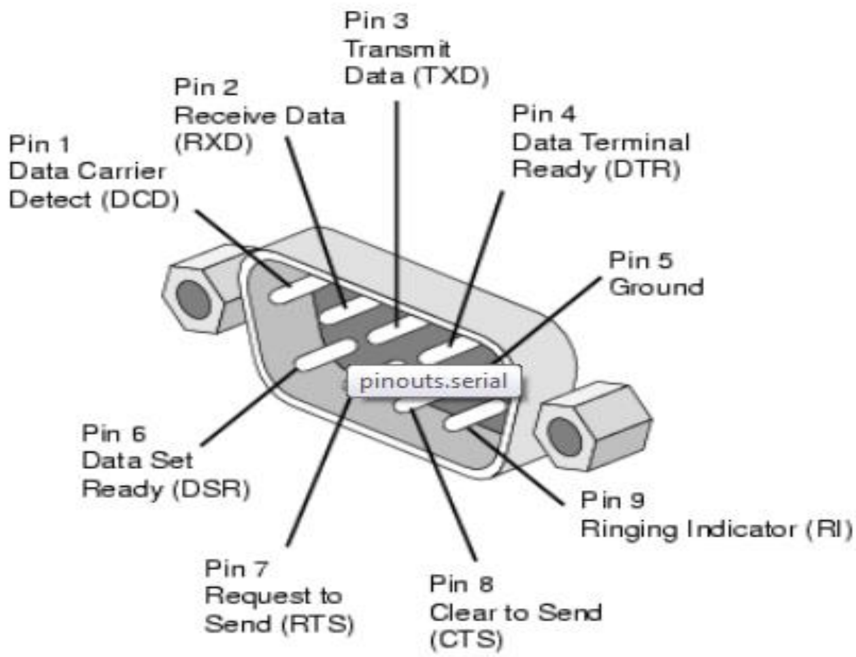


Fig 3.2.8 RS-232

PINOUTS AND DESCRIPTION OF A SERIAL PORT

Name	Pin	Description
Transmitted Data (TxD)	3	Serial data output
Received Data (RxD)	2	Serial data input
Request to Send (RTS)	7	This line informs the DCE (Modem) that the DTE (PC) is ready to exchange data

Clear to Send (CTS)	8	This line indicates that the DCE is ready to exchange data
Data Terminal Ready (DTR)	4	Asserted by DTE to indicate that it is ready to be connected
Data Set Ready (DSR)	6	Asserted by DCE to indicate the DCE is powered on and is ready to receive commands or data for transmission from the DTE
Data Carrier Detect (DCD)	1	Asserted by DCE when a connection has been established with remote equipment
Ring Indicator (RI)	9	Asserted by DCE when it detects a ring signal from the telephone line

Table 3.3 Pinouts and description of a serial port

EMBEDDED C

Embedded C is the most popular embedded software language in the world. Most embedded software is written in Embedded C.It is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded systems.

Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations. The C programming language is perhaps the most popular programming language for programming embedded systems.

Most C programmers are spoiled because they program in environments where not only there is a standard library implementation, but there are frequently a number of other libraries available for use. The cold fact is, that in embedded systems, there rarely are many of the libraries that programmers have grown used to, but occasionally an embedded system might not have a complete standard library, if there is a standard library at all.

Few embedded systems have capability for dynamic linking, so if standard library functions are to be available at all, they often need to be directly linked into the executable. Oftentimes, because of space concerns, it is not possible to link in an entire library file, and programmers are often forced to "brew their own" standard c library implementations if they want to use them at all. While some libraries are bulky and not well suited for use on microcontrollers, many development systems still include the standard libraries which are the most common for C programmers.

C remains a very popular language for micro-controller developers due to the code efficiency and reduced overhead and development time. C offers low-level control and is considered more readable than assembly. Many free C compilers are available for a wide variety of development platforms.

The compilers are part of an IDEs with ICD support, breakpoints, single-stepping and an assembly window. The performance of C compilers has improved considerably in recent years, and they are claimed to be more or less as good as assembly, depending on who you ask. Most tools now offer options for customizing the compiler optimization. Additionally, using C increases portability, since C code can be compiled for different types of processors.

BASIC CONCEPTS OF EMBEDDED C AND EMBEDDED PROGRAMMING

Embedded C, even if it's similar to C, and embedded languages in general requires a different kind of thought process to use. Embedded systems, like cameras or TV boxes, are simple computers that are designed to perform a single specific task. They are also designed to be efficient and cheap when performing their task.

For example, they aren't supposed to use a lot of power to operate and they are supposed to be as cheap as possible. As an embedded system programmer, you will have simple hardware to work with. You will have very little RAM, ROM and very little processing power and stack space. The reason why most embedded systems use Embedded C as a programming language is because Embedded C lies somewhere between being a high level language and a low level language. Embedded C, unlike low level assembly languages, is portable.

It can run on a wide variety of processors, regardless of their architecture. Unlike high level languages, Embedded C requires less resources to run and isn't as complex. Some experts estimate that C is 20% more efficient than a modern language like C++. Another advantage of Embedded C is that it is comparatively easy to debug.

EMBEDDED C COMPILERS

There are a variety of different compilers on the market, manufactured by different companies that use Embedded C. One of the more popular ones is the Keil compiler. Because of this, Embedded C is also sometimes known as Keil C.

Embedded C has several keywords that are not present in C (learn more about the concept of keywords in this course). These keywords are associated with operations needed by microprocessors. You will need to be familiar with all of them to be able to write Embedded C programs.

Unsigned char data a;

Here, the unsigned char declaration is like a normal C declaration. We just added the data keyword, which tells the microcontroller to store the unsigned char a in the internal data memory.

bdata: The bdata keyword lets you store a declared variable in the bit addressable memory. Take a look at this example:

Unsigned char bdata a;

This is similar to the data declaration we showed you above. You have to access bdata variables in a different way, however using This keyword lets you execute a function by letting it access a register bank. There are three possible values: 1, 2 and 3.

EMBEDDED SYSTEMS PROGRAMMING

Embedded systems programming is different from developing applications on a desktop computers. Key characteristics of an embedded system, when compared to PCs, are as follows:

- Embedded devices have resource constraints(limited ROM, limited RAM, limited stack space, less processing power)
- Components used in embedded system and PCs are different; embedded systems typically uses smaller, less power consuming components. Embedded systems are more tied to the hardware.

EMBEDDED SYSTEMS USING DIFFERENT TYPE OF LANGUAGES:

- Machine Code
- Low level language, i.e., assembly
- High level language like C, C++, Java, Ada, etc.
- Application level language like Visual Basic, scripts, Access, etc.

ADVANTAGES

- It is small and reasonably simpler to learn, understand, program and debug.
- C Compilers are available for almost all embedded devices in use today, and there is a large pool of experienced C programmers.
- Unlike assembly, C has advantage of processor-independence and is not specific to any particular microprocessor/ microcontroller or any system. This makes it convenient for a user to develop programs that can run on most of the systems.
- As C combines functionality of assembly language and features of high level languages, C is treated as a ‘middle-level computer language’ or ‘high level assembly language’
- It is fairly efficient
- It supports access to I/O and provides ease of management of large embedded projects

Many of these advantages are offered by other languages also, but what sets C apart from others like Pascal, FORTRAN, etc. is the fact that it is a middle level language; it provides direct hardware control without sacrificing benefits of high level languages.

PROTEUS

Proteus is a software technology that allows creating clinical executable decision support guidelines with little effort. Once a guideline for a condition has been created, it can be executed to provide stepwise advice for any patient having that condition.

This site is dedicated to the Proteus executable guidelines model, tools based on the Proteus approach and the automated guidelines created using those tools.

A software tool that allows creating and executing clinical decision support guidelines using the Proteus approach is available. The tool called Protean may be downloaded from here. Protean allows creating new guidelines or editing existing ones very easily. Much of the editing is done by dragging and dropping.

Proteus (Pro**cesses and** T**ransactions** E**ditable by** Us**ers)** is a model that describes creation of clinical guidelines with **Knowledge Components (KCs).**

Each KC represents a clinically identifiable activity and is available to the clinician as executable knowledge. Experts at disparate locations may manage the individual knowledge components, while the clinicians benefit from the state-of-the-art knowledge. Additionally, the KCs offer a template for capturing data pertaining to the clinical activity that they represent, to provide a basis for the EMR. Since the KCs represent discretely identifiable clinical activities they also allow attaching related elements from non-clinical processes.

Each such non-clinical process can be assigned a separate layer, with components within it communicating with a logically related KC in the clinical guideline. This allows conceiving of an integrated healthcare information system with logically related parts and unlimited extensibility.

Its strongest points are:

- powerful string manipulation;
- comprehensibility of Proteus scripts;
- availability of advanced data structures: arrays, queues (single or double), stacks, bit maps, sets, AVL trees.
- The language can be extended by adding user functions written in Proteus or DLLs created in C/C++.

PROTEUS OVERVIEW

The Proteus guidelines are created with modular entities called Knowledge Components (KCs). Each KC represents a clinical activity and is available to the clinician as a module of executable knowledge with its own intelligence.

- The KCs may be easily modified. Simple drag and drop operations constitute significant part of editing.
- The KCs may be reused. For example, a KC created for diagnosis of diabetes can be used in guidelines as disparate as “investigation of coma”, “routine preoperative checkups for major elective surgery”, “investigation of unexplained weight loss” and “evaluation for risk of infection”. One can simply drop a KC in a guideline and begin using it. The KCs are also shareable, therefore anyone who authors guidelines can have a library of pre-built KCs at their disposal to drag and drop in their guideline.
- Experts at remote locations may manage individual KCs, keeping them in sync with the current medical concepts, while the clinicians automatically get the state-of-the-art executable knowledge. This is akin to opening a web page using a hyperlink; the user gets the fresh content by clicking on the same URL when the author of the web page updates it. Unlike a web page however, the

Proteus KCs are executable knowledge and not passive information. Each guideline may have many KCs, each being updated by a different expert or a group of experts.

- The intelligent decision-making in the KC comes from the Inference Tools in the Proteus approach. Anything that can make the inferences that a KC needs can be declared its inference tool. Simple software algorithms, sophisticated artificial intelligence tools or even remote human experts can be specified as inference tools for KCs. The inference tool can be as easily swapped as they can be declared. Therefore, if a tool with better inference capabilities becomes available, it can be used to replace the previous one in a few simple steps.
- The KCs offer a template for capturing data pertaining to the clinical activity that they represent and serve as components of an Electronic Medical Record.
- Since the KCs represent discretely identifiable clinical activities they also allow attaching related elements from the non-clinical processes of healthcare. Each such non-clinical process can be assigned a separate layer, with components within it communicating with a logically related KC in the clinical process. For example, execution of a KC representing Colonoscopy in the clinical process may be linked with an event that increments the list of billable items for the patient.
- The latter event exists in a parallel process layer called “billing” which gets its hints from the core clinical process as it progresses. This allows conceiving of an integrated healthcare information system with logically related parts and unlimited extensibility.

LANGUAGE FEATURES

- At first sight, Proteus may appear similar to Basic because of its straight syntax, but similarities are limited to the surface:
- Proteus has a fully functional, procedural approach;
- variables are untyped, do not need to be declared, can be local or public and can be passed by value or by reference;
- all the typical control structures are available (if-then-else; for-next; while-loop; repeat-until; switch-case);
- New functions can be defined and used as native functions.
- Data types supported by Proteus are only three: integer numbers, floating point numbers and strings. Access to advanced data structures (files, arrays, queues, stacks, AVL trees, sets and so on) takes place by using handles, i.e. integer numbers returned by item creation functions.
- Type declaration is unnecessary: variable type is determined by the function applied – Proteus converts on the fly every variable when needed and holds previous data renderings, to avoid performance degradation caused by repeated conversions.
- There is no need to add parenthesis in expressions to determine the evaluation order, because the language is fully functional (there are no operators).
- Proteus includes hundreds of functions for:
- accessing file system;
- sorting data;
- manipulating dates and strings;
- interacting with the user (console functions)
- Calculating logical and mathematical expressions.

CHARACTERISTICS

- **Interpreted language:** Proteus is an interpreter which pseudo-compiles the scripts to memory, checking their syntax and subsequently executing them against the input;
- **Multi-language support:** Proteus is available in several languages;
- **No data types:** all variables can be used as integer numbers, floating point numbers or strings; variables are interpreted according to the functions being applied - Proteus keeps different representations of their values between calls, to decrease execution time in case of frequent conversions between one type and the other;
- **No pre-allocated structures:** all data used by Proteus are dynamically allocated at execution time; there are no limits on: recursion, maximum data size, number of variables, etc.;
- **No operators:** Proteus is a completely functional language - there are no operators; thus, there is no ambiguity when evaluating expressions and parenthesis are not needed;
- **Large library of predefined functions:** Proteus is not a toy-language, it comes with hundreds of library functions ready to be used for working on strings, dates, numbers, for sorting, searching and so on;
- three models for dates (English, American, Japanese), with functions to check them and to do calculations according to gregorian calendar;
- epoch setting for 2-digit-year dates;
- support for time in 12 and 24 hour format;
- support for simple (Dos-like) and extended (Unix™-like) regular expressions, in all versions;
- Debug function to verify variable status during execution.

VERSIONS

- Proteus Dos: it works on Ms-Dos™ 5.0 (or greater) and supports long file names under Windows™ 95/98/ME/2000/XP; it does not include all Windows™-specific functions (sockets, DAO, pipes, etc.);
- Proteus Win32: it works on Windows 98™ or greater (Windows 95™ is supported with a special version);
- Proteus Service: it works on Windows™ NT/2000/XP; it can be installed as a service;
- Proteus ISAPI: similar to Proteus Win32, it can be used through Microsoft® Internet Information Server™;
- Proteus Unix™: similar to Dos version (does not include console functions).
- The interpreter can be compiled (on request) with keywords and messages in Italian or English; this version has English keywords and messages.

ARDUINO SOFTWARE (IDE)

The Arduino Integrated Development Environment or Arduino Software (IDE) contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

3.3 CONNECTION SETUP

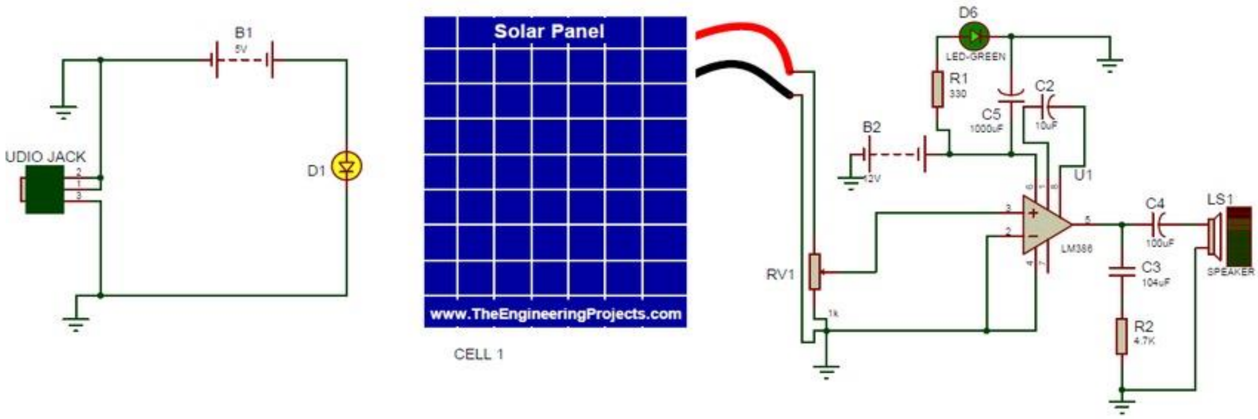


Fig 3.3 Connection setup

3.4 EXPERIMENTAL SETUP

The proposed Li-Fi system offers significant advancements and practical advantages with its extended transmission distance and coverage. With the distance between Li-Fi transmission improved from 20 cm to 60 cm, users benefit from an extended transmission range, facilitating connections across greater distances. Moreover, the wider transmission range ensures broader coverage, allowing seamless connectivity in larger spaces such as offices, homes, and public areas without compromising signal strength. This improvement also leads to reduced interference from nearby devices or obstacles, enhancing the reliability and stability of connections. Additionally, users gain increased flexibility in device placement within the coverage area, enabling convenient setup in workspaces or homes without signal loss concerns.

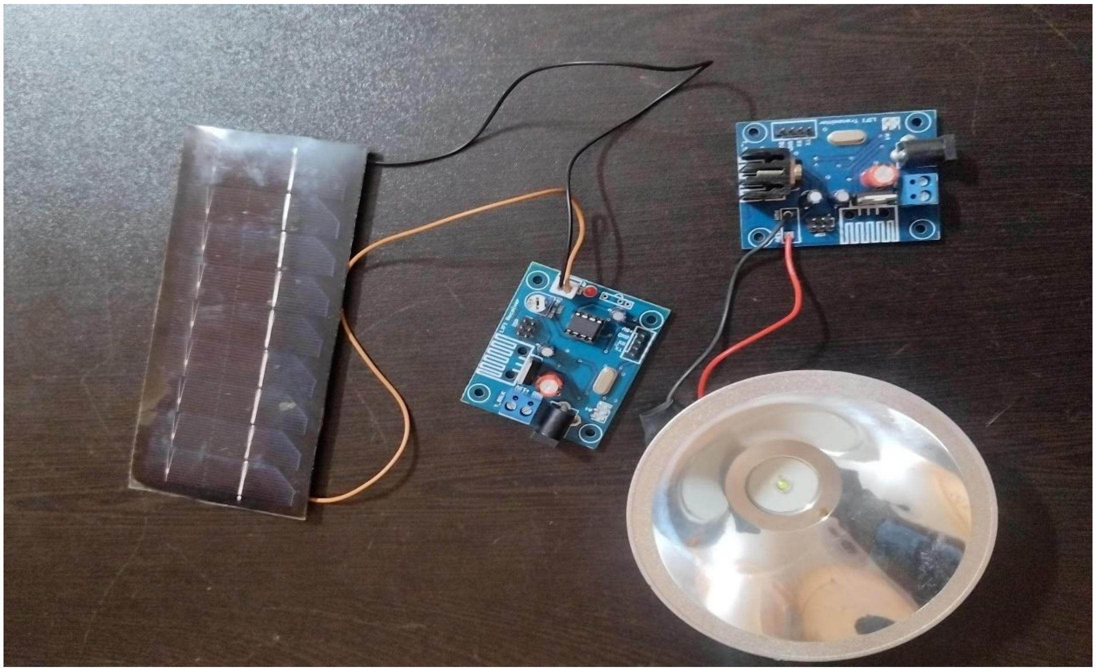


Fig 3.4.1 Experimental setup of the transmitters and receiver

The expanded coverage area enhances accessibility to Li-Fi technology, making it more feasible for various applications, including indoor navigation and internet access in public venues.

Despite the increased transmission distance, the system maintains high data transfer rates, offering faster and more efficient communication compared to traditional wireless technologies like Wi-Fi. Moreover, the enhanced security features ensure confidentiality in corporate environments by confining Li-Fi signals within shorter ranges, minimizing external interception risks.

Lower latency and energy efficiency further enhance performance, while seamless integration with existing lighting infrastructure simplifies deployment and reduces implementation costs. These features collectively underscore the practical benefits of the proposed Li-Fi system, making it a compelling choice for modern communication needs.

3.5 FEATURES AND BENEFITS OF PROPOSED SYSTEM

- Extended transmission range from 20 cm to 60 cm.
- Wider coverage area for seamless connectivity.
- Reduced interference for more reliable connections.
- Flexible device placement within coverage area.
- Improved accessibility to Li-Fi technology.
- High data transfer rates maintained.
- Enhanced security with shorter signal ranges.
- Lower latency for real-time communication.
- Energy-efficient transmission.
- Seamless integration with existing lighting infrastructure.

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CHAPTER IV

RESULTS AND DISCUSSIONS

The findings and discussions from the Li-Fi (Light Fidelity) project indicate a promising shift towards a revolutionary wireless communication method. By employing commercially available LED light bulbs, the project has achieved significant advancements across various metrics. This overview highlights the project's accomplishments, the challenges overcome, and the wider implications of its results.

A key outcome of the project involves optimizing data transfer rates through LED modulation. Through extensive experimentation, the Li-Fi system surpassed traditional Wi-Fi speeds by fine-tuning LED flickering rates. This breakthrough underscores the potential of visible light waves for high-speed communication, reshaping wireless networks.

Addressing interference and security concerns has been crucial. Li-Fi has shown inherent resistance to interference, and robust security measures have been effective in countering vulnerabilities, positioning it as a secure alternative to traditional wireless systems.

Li-Fi's applicability in specialized environments, such as aircraft cabins, has been successful, overcoming challenges faced by radio-based systems. This has implications for industries with specific communication needs in confined spaces, offering a reliable solution.

Efforts to extend Li-Fi's range through optimized LED layouts have yielded positive results, enhancing its adaptability for various scenarios. The development of an intelligent controller has also been significant, efficiently encoding data into LEDs.

These findings position Li-Fi as a viable alternative in wireless communication, showcasing high-speed transfer rates, interference resistance, security, and adaptability. Challenges addressed include LED modulation, security, and range extension, with ongoing refinement crucial for its continued advancement.

In conclusion, Li-Fi holds transformative potential in wireless communication, evident in its optimized data transfer, interference resistance, security, and adaptability. These insights contribute to the discourse on connectivity's future, where visible light waves may shape the wireless landscape.

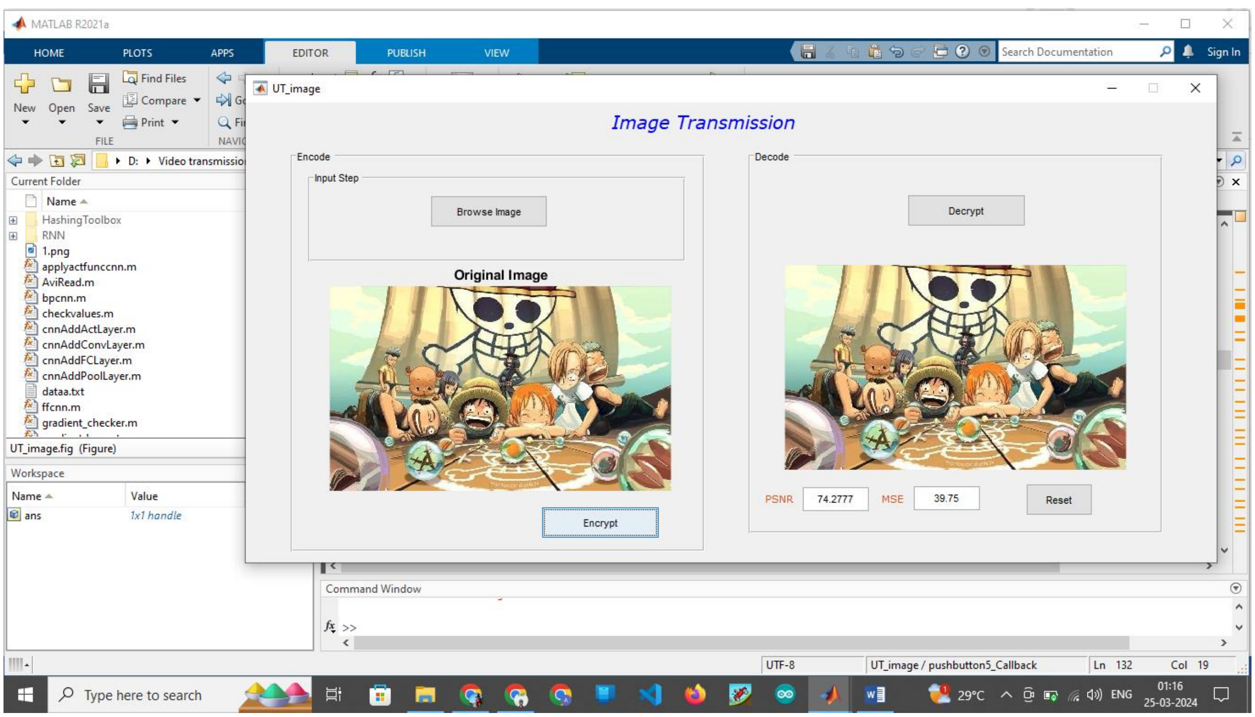

Fig 4.1 Matlab Output

CHAPTER V

CONCLUSION AND FUTURE ENHANCEMENTS

The Li-Fi project represents a significant leap forward in wireless communication, demonstrating the potential of visible light waves. Through the utilization of LED light bulbs, Li-Fi has surpassed traditional wireless systems in data transfer rates, interference resistance, and adaptability to specialized environments. Not only does the project address current challenges, but it also lays the foundation for future improvements and widespread adoption of Li-Fi.

By modulating LED light sources, the project achieved breakthroughs in high-speed communication, showcasing visible light's capability to outperform traditional Wi-Fi. Li-Fi's resistance to interference, proven through real-world experiments and robust security measures, ensures reliability, particularly in settings like aviation or healthcare.

Li-Fi's adaptability to various environments, such as aircraft cabins, highlights its potential where traditional wireless systems struggle. Optimizing LED layouts has extended Li-Fi's transmission range, making it suitable for complex environments like large industrial spaces and smart cities.

The development of an intelligent controller streamlines Li-Fi implementation, enhancing its user-friendliness and accessibility. Looking ahead, ongoing research will focus on refining LED modulation and security protocols, while standardization efforts aim to integrate Li-Fi seamlessly into existing frameworks

Furthermore, Li-Fi's potential in emerging technologies like IoT and 5G networks opens new avenues for connected and smart environments. In conclusion, the Li-Fi project not only showcases visible light communication's transformative potential but also sets the stage for a future where Li-Fi becomes ubiquitous, advancing wireless connectivity.

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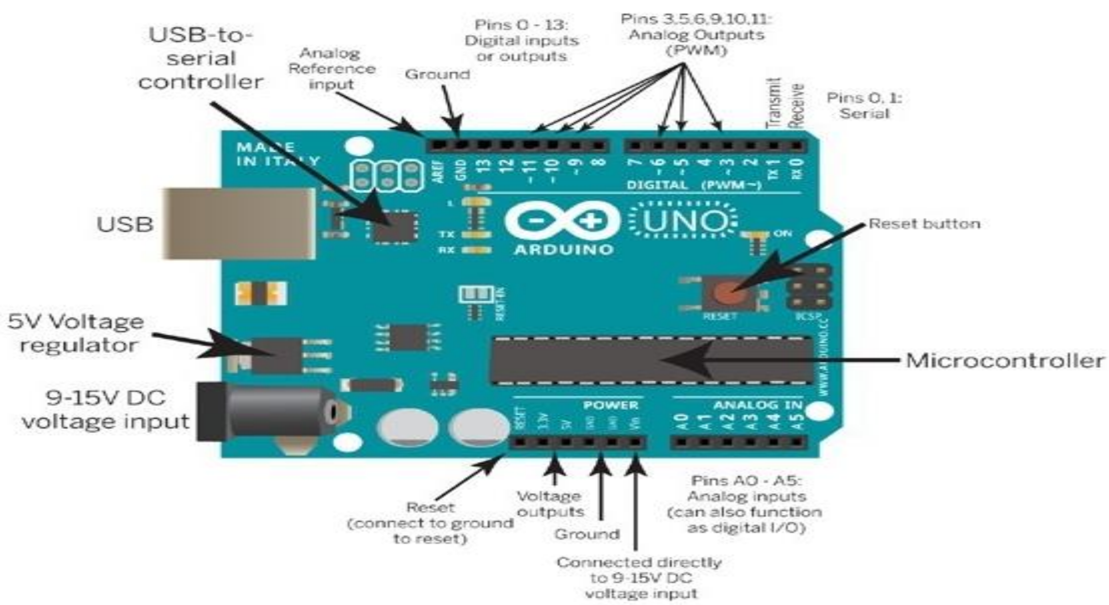
APPENDIX

1.ARDUINO UNO:

An Arduino is actually a microcontroller based kit which can be either used directly by purchasing from the vendor or can be made at home using the components, owing to its open source hardware feature. It is basically used in communications and in controlling or operating many devices. It was founded by Massimo Banzi and David Cuartielles in 2005. The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.



Arduino Pin Diagram

FEATURES:

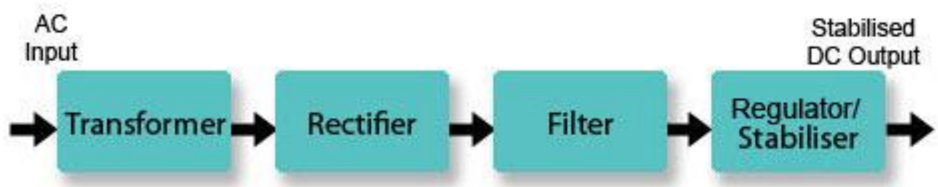
- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- Flash Memory: 32 KB (0.5 KB used by bootloader)
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- USB Interface: Type-B
- Power Supply: USB or external DC power source (7-12V)
- Programming Language: Arduino (based on Wiring)
- Integrated Development Environment (IDE): Arduino IDE
- Compatibility: Works with a wide range of shields and sensors

APPLICATION:

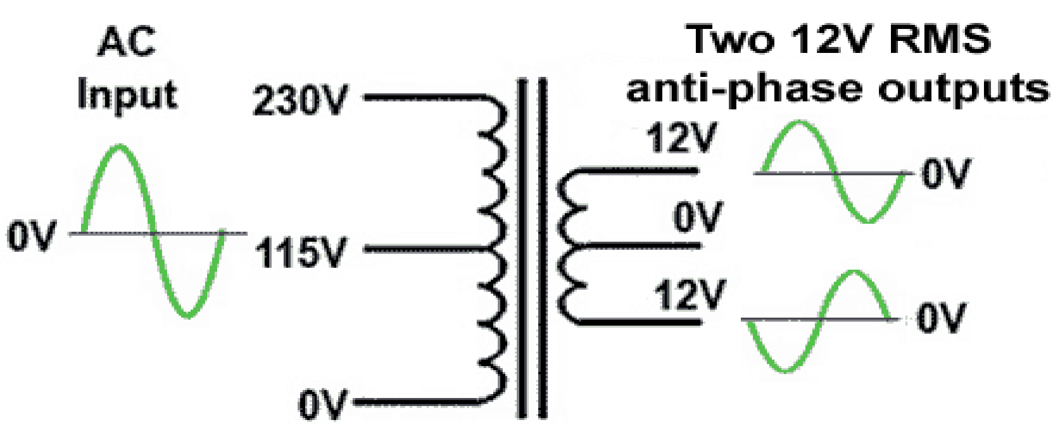
- DIY Electronics Projects
- Prototyping
- Education
- IoT (Internet of Things)
- Data Logging
- Wearable Technology
- Automation
- Remote Control Systems
- Interactive Art
- Scientific Experiments

2.POWER SUPPLY

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to other.

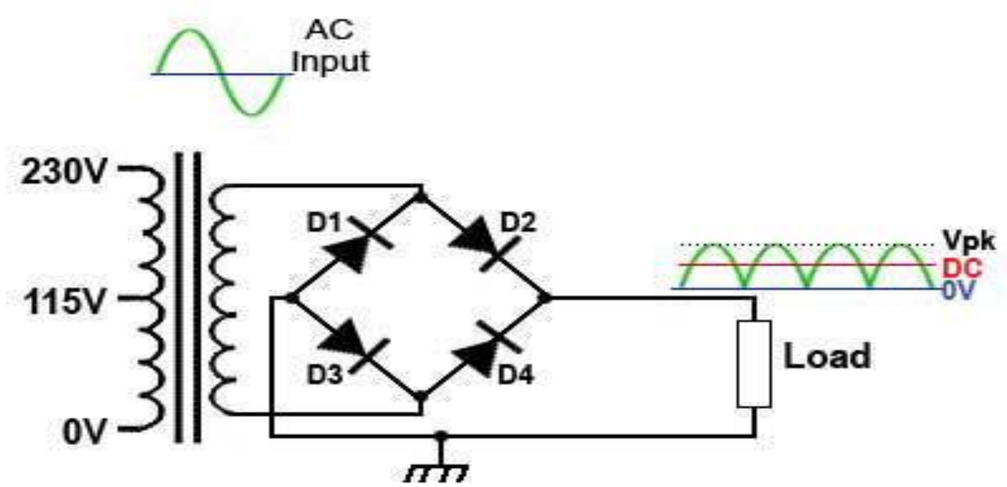


Basic power supply the input power transformer has its primary winding connected to the mains (line) supply. A secondary winding, electro-magnetically coupled but electrically isolated from the primary is used to obtain an AC voltage of suitable amplitude, and after further processing by the PSU, to drive the electronics circuit it is to supply.



The transformer stage must be able to supply the current needed. If too small a transformer is used, it is likely that the power supply's ability to maintain full output voltage at full output current will be impaired. With too small a transformer, the losses will increase dramatically as full load is placed on the transformer.

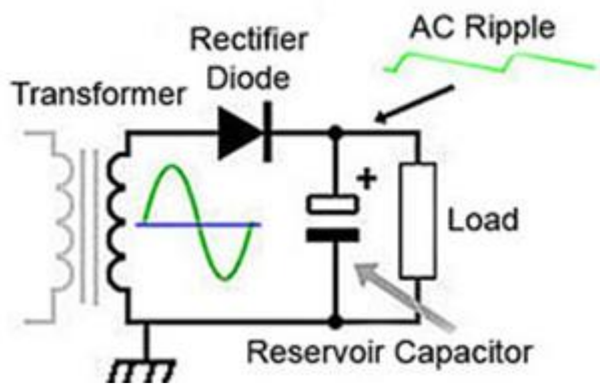
3.THE RECTIFIER STAGE:



Rectifier circuit is used , to convert the AC input is converted to DC. The full wave bridge rectifier uses four diodes arranged in a bridge circuit to give full wave rectification without the need for a centre-tapped transformer. An additional advantage is that, as two diodes are conducting at any one time, the diodes need only half the reverse breakdown voltage capability of diodes used for half and conventional full wave rectification. The bridge rectifier can be built from separate diodes or a combined bridge rectifier can be used.

FILTER:

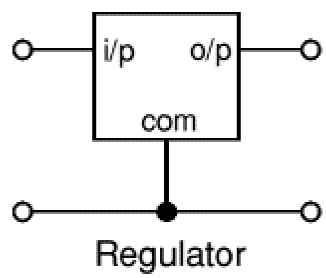
A typical power supply filter circuit can be best understood by dividing the circuit into two parts, the reservoir capacitor and the low pass filter. Each of these parts contributes to removing the remaining AC pulses, but in different ways. Electrolytic capacitor used as a reservoir capacitor, so called because it acts as a temporary storage for the power supply output current. The rectifier diode supplies current to charge a reservoir capacitor on each cycle of the input wave

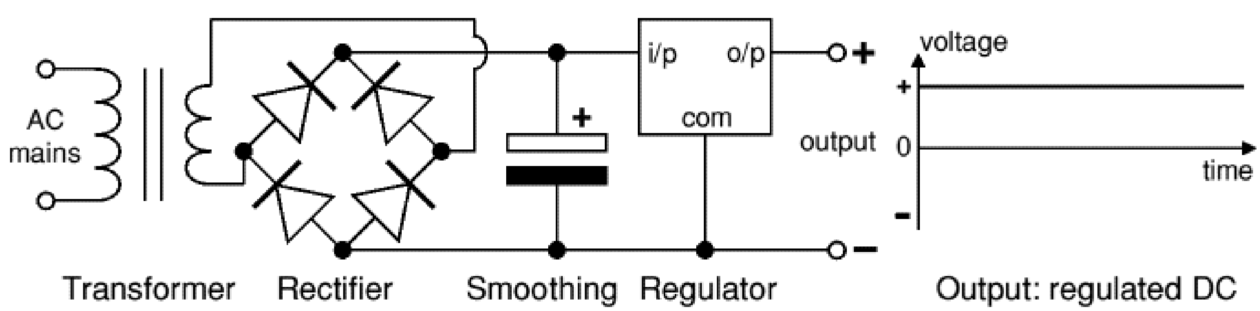


Of course, even though the reservoir capacitor has large value, it discharges as it supplies the load, and its voltage falls, but not by very much. At some point during the next cycle of the mains input, the rectifier input voltage rises above the voltage on the partly discharged capacitor and the reservoir is re-charged to the peak value Vpk again.

4.**REGULATOR:**

Voltage regulator ICs are available with fixed or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current and overheating.



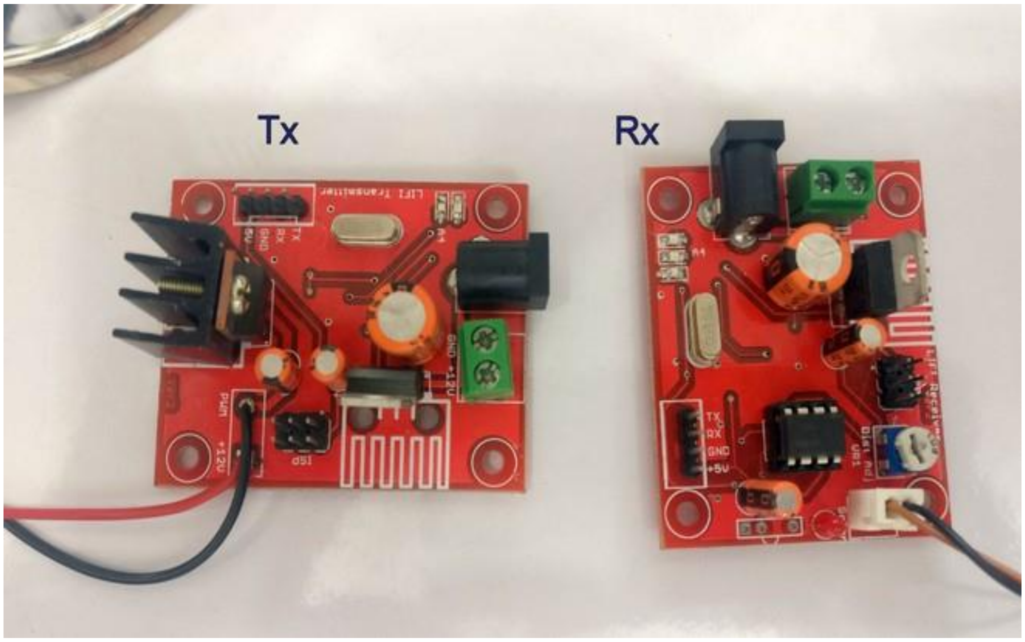


5. LI-FI:

Li-Fi technology is a ground-breaking light-based communication technology, which makes use of light waves instead of radio technology to deliver data. Using the visible light spectrum, Li-Fi technology can transmit data and unlock capacity which is 10,000 times greater than that available within the radio spectrum. The visible light spectrum is plentiful, free and unlicensed, mitigating the radio frequency spectrum crunch effect.

Li-Fi technology will in future enable faster, more reliable internet connections, even when the demand for data usage has outgrown the available supply from existing technologies such as 4G, LTE and Wi-Fi. It will not replace these technologies, but will work seamlessly alongside them.Using light to deliver wireless internet will also allow connectivity in environments that do not currently readily support Wi-Fi, such as aircraft cabins, hospitals and hazardous environments.

LIFI IN FUTURE



LIFI Transmitter and Receiver Module

FEATURES:

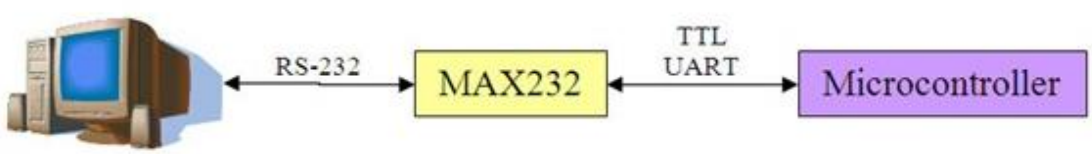
- High-speed data transmission via visible light.
- Uses LED light sources for communication.
- Enhanced security and immunity to interference.
- Energy-efficient technology.
- Versatile deployment in various environments.
- Integration with existing lighting infrastructure.
- Supports dense network configurations.
- Requires line-of-sight communication.
- Compatible with existing devices.
- Potential for targeted communication.

APPLICATIONS:

- Indoor wireless communication.
- Retail, hospitality, and customer services.
- Industrial automation and real-time monitoring.
- Healthcare data transmission.
- In-flight and transportation connectivity.
- Smart lighting and IoT integration.
- Underwater communication.
- Military and defense applications.
- Disaster recovery and emergency response.
- Secure data transfer in sensitive environments.

6.UART:

The Universal Asynchronous Receiver/Transmitter (UART) controller is the key component of the serial communications subsystem of a computer. UART is also a common integrated feature in most microcontrollers. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes.



Serial transmission of digital information (bits) through a single wire or other medium is much more cost effective than parallel transmission through multiple wires. Communication can be “full duplex”

TTL level UART:

Most microcontrollers with UART use TTL (Transistor-transistor Logic) level UART. It is the simplest form of UART. Both logic 1 and 0 are represented by 5V and 0V respectively.

The TTL level UART is commonly used in the communications between microcontrollers and ICs. Only 2 wires are required for the full duplex communications as illustrated in the picture below.

RS-232:

RS-232 (Recommended Standard 232) is a standard for serial binary data signals connecting between a Data Terminal Equipment (DTE) and a Data Communication Equipment (DCE). It is commonly used in computer serial ports. One of the significant differences between TTL level UART and RS-232 is the voltage level. Valid signals in RS-232 are ±3 to – ±15V, and signals near 0V is not a valid RS-232 level.

Besides voltage level, the RS-232 also has a few extra pins specifically designed for the communication between PC and modem. The pinots of the DB-9 and their functions are shown below.

CONFERENCES

CONFERENCES:

- Third International Conference on Smart Technologies and Systems for Next Generation Computing 2024