A

MAJOR PROJECT REPORT ON

DEVELOPMENT OF CHILD SAFFETY ALERT SYSTEM IN CAR

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Kandlakoya(V), Medchal(M), Telangana – 501401

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CERTIFICATE

This is to certify that the major-project work entitled **“DEVELOPMENT OF CHILD ALERT SYSTEM IN CAR”** is being submitted by **G.SOUMYA SRI** bearing Roll No **218R1A0421, G.RISHITHA** bearing Roll No **218R1A0422, G.VENKATESH** bearing Roll No **218R1A0423, J.ADITYA SAI** bearing Roll No **218R1A0424** in B.Tech IV-II semester, Electronics and Communication Engineering is a record Bonafide work carried out during the academic year 2024-25. The results embodied in this report have not been submitted to any other University for the award of any degree.

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DECLARATION

We hereby declare that the major project entitled **"DEVELOPMENT OF CHILD SAFETY ALERT SYSTEM IN CAR"** is the work done by us in campus at **CMR ENGINEERING COLLEGE,** Kandlakoya during the academic year 2024-2025 and is submitted as major project in partial fulfilment of the requirements for the award of degree of **BACHELOR OF TECHNOLOGY** in **ELECTRONICS AND COMMUNICATION ENGINEERING FROM JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY, HYDERABAD.**

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ABSTRACT

This paper discusses the development of a car seat alert system through telegram application to design and develop a car seat alert system for babies that have been left in vehicles and get heatstroke deaths. This type of accident is called vehicular heatstroke and it is very dangerous to a baby because their body overheats 3-5 times faster than an adult body. Plus, the inside of a vehicle is heating up very quickly and it very concerns parents to bring their child to travel using car. Nowadays, heatstroke deaths of children in vehicles are quite encouraging and every year the number of cases is increasing. In an overwhelming majority of child vehicular heatstroke deaths, it was loving, responsible parents that unknowingly left the child. This project was created to inform and alert the parents out there when they might forget their child is left under any circumstances.

To make sure this project system is more practical, Node MCU is used as a micro controller to control all the input and output devices in this system. As to alert parents when this carelessness is happening the alerts are provided in this system. Apart from that, LCD is used to display the presence of the child at the seat and temperature value inside. Temperature sensor module is used to sense the temperature of baby and alerts the parents if the temperature raises extremely. As to ensure the goals stated will be achieved, significant research has been made thoroughly that will act as references throughout these studies for this project.

Ultimately, the goal of this project is to provide a life-saving solution that not only warns parents about heatstroke risks but also offers peace of mind. With an increasing number of vehicular heatstroke deaths each year, especially among children, this project aims to be part of a much-needed technological solution to reduce these tragic incidents and ensure the safety of young children in vehicle

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INTRODUCTION

With advancement in technology it is is designed to prevent tragic incidents where children are accidentally left unattended in vehicles. This system utilizes advanced sensors and alert mechanisms to detect the presence of a child inside the car after the engine is turned off. By integrating technologies such as temperature sensors, motion detectors, and GSM modules, the system can notify parents or guardians through alarms and mobile alerts, ensuring timely intervention. With increasing cases of heatstroke-related fatalities among children left in hot cars, this safety measure serves as a crucial innovation to enhance child protection and prevent accidents.This system utilizes advanced sensors and alert mechanisms to detect the presence of a child inside the car after the engine is turned off. By integrating technologies such as temperature sensors, motion detectors, and GSM modules, the system can notify parents or guardians through alarms and mobile alerts, ensuring timely intervention.

1.1 COMMUNICATION SYSTEM

A Communication System is an essential framework that facilitates the exchange of information between two or more entities using a structured process. It involves the transmission, propagation, and reception of signals through various mediums such as air, cables, or optical fibers. The system typically comprises key components, including a transmitter, which encodes and sends the message; a communication channel, which carries the signal; and a receiver, which decodes and interprets the transmitted information. Communication systems can be classified based on their mode of operation, such as analog or digital, wired or wireless, and simplex, half-duplex, or full-duplex communication.

With technological advancements, modern communication systems incorporate cutting-edge technologies such as satellite communication, fiber optics, 5G wireless networks, and the Internet of Things (Iot), enabling high-speed, efficient, and reliable data transfer. These systems are fundamental to various applications, including telecommunications, broadcasting, remote sensing, and networking. From traditional postal services to modern-day instant messaging.

A Communication System is a structured framework that enables the transmission and reception of information between two or more entities through various mediums. It consists of essential components such as a transmitter, communication channel, receiver, and signal processing mechanisms. Communication systems can be classified based on their mode of transmission (analog or digital), medium (wired or wireless), and direction (simplex, half-duplex, or full-duplex). With technological advancements, modern communication systems integrate cutting-edge technologies like optical fiber, satellite communication, 5G networks, and the Internet of Things (IoT) to enhance efficiency, speed, and reliability. These systems play a crucial role in various domains, including telecommunications, broadcasting, healthcare, military, and business, ensuring seamless connectivity across the globe. As communication technology continues to evolve, it significantly impacts daily life, revolutionizing the way people interact, share information, and conduct business in the digital age.

A well-structured communication system is essential for the seamless transfer of information across the globe. With rapid technological advancements, modern communication systems continue to revolutionize the way people interact, work, and live. Whether through satellite communications, high-speed internet, or AI-driven automation, the future of communication is geared toward greater efficiency, security, and connectivity.

1.2 HISTORY AND FUTURE

Communication is the foundation of human civilization, enabling the exchange of ideas, knowledge, and emotions. Over time, communication methods have evolved from primitive symbols to modern digital networks that connect people globally in real-time. The journey of communication has been marked by groundbreaking inventions, such as the printing press, the telegraph, the telephone, and the internet, each revolutionizing how people interact. As we step into the future, emerging technologies like 5G, artificial intelligence (AI), quantum communication, and brain-computer interfaces promise to redefine the way we share information. This article explores the remarkable history of communication and its future trends.

In ancient times, humans relied on cave paintings, gestures, and primitive signals such as smoke and drum beats to communicate over distances. As civilizations advanced, the invention of written language, such as cuneiform and hieroglyphics, allowed humans to record and transmit complex ideas. The advent of the printing press in the 15th century revolutionized mass communication by making books and newspapers widely accessible, thereby fueling the spread of knowledge and sparking the Renaissance. The 19th century marked a new era with the invention of the telegraph, which enabled long-distance communication using Morse code, followed by the telephone, which made real-time voice communication possible.

The 20th century saw the rise of wireless communication through radio and television, connecting people across vast distances and creating a global culture of shared information. With the advent of the internet and digital communication in the late 20th century, the world became more interconnected than ever, allowing for the instantaneous exchange of information. As we look to the future, communication will continue to evolve with innovations like 5G, artificial intelligence, and quantum communication, all of which promise to make connectivity faster, more secure, and more immersive. Technologies such as brain-computer interfaces and augmented reality are poised to revolutionize the way we interact, making communication more intuitive and seamless than ever before. As the boundaries of what is possible in communication continue to expand, we are entering a new era where distance and time will no longer be obstacles.

1.3 REAL TIME SYSTEMS

The System is designed to process and transmit information within a specific time frame, where timely delivery of data is crucial for proper functioning. These systems are especially important in applications like telecommunications, autonomous vehicles, and medical devices, where delays or missed deadlines could lead to failures or safety risks. Real-time communication can be classified into hard, soft, and firm systems, with hard real-time systems requiring strict adherence to timing constraints, such as those used in aviation or robotic surgery. In contrast, soft real-time systems, like video conferencing or VoIP calls, allow for some delay without significant consequence. The rise of 5G technology, edge computing, and IoT is enhancing the capabilities of real-time systems by offering lower latency, higher speeds, and more reliable data transfer. However, challenges such as network congestion, error handling, and maintaining quality of service (QoS) remain significant. As technology advances, real-time communication systems continue to evolve, enabling more seamless and efficient global connectivity, critical in various sectors including healthcare, defense, and autonomous systems.

1. **Timeliness :** A real-time communication system must provide timely delivery of data. If a system fails to meet deadlines, it is considered unreliable.
2. **Deterministic Behavior:** The system must perform consistently under varying conditions, ensuring that data transmission and processing times are predictable.
3. **Low Latency:** Real-time communication demands low latency, which refers to the minimal delay between data transmission and reception. It is particularly crucial for applications like live video streaming or voice calls, where delays can disrupt user experience.
4. **Reliability:** Real-time systems must be highly reliable and capable of handling unexpected network conditions or failures without affecting performance.
5. **Synchronization:** In systems that involve multiple components, such as a network of devices, synchronization ensures that data is processed in a coordinated manner without conflicts or data loss.

1. **Hard Real-Time Systems**: These systems have strict timing constraints. Missing a deadline could result in catastrophic failures. For example, communication systems used in

aviation, medical devices, or automated vehicles are hard real-time systems, where data must be delivered within a strict timeframe to ensure safety and correct operation.

2. **Soft Real-Time Systems:** These systems have more relaxed timing requirements, where delays do not cause immediate harm, but performance degrades. Examples include video conferencing or VoIP (Voice over Internet Protocol) systems, where occasional delays might affect the user experience but do not cause system failure.

1.4 OVERVIEW OF PROJECT

Recent years have seen a rise in the number of children who die from heatstroke after being left alone in a car. Heatstroke is a drastic medical disorder that is devastating. It unexpectedly affects safe people and many deaths. Those who survive may suffer permanent neurological damage. Heatstroke poses a safety threat worldwide. Heatstroke usually occurs in the summertime in an epidemic fashion. It features a body temperature above 40 degrees Celsius, an hydrosis, extreme disorientation, coma and delirium. The elderly and young children are the ones who are most at risk for heatstroke. Children are especially vulnerable to experiencing heatstroke because their body temperatures rise three to five times faster than that of an adult..

The susceptibility of children to a classic heat stroke is due to a high ratio of surface area to mass, which results in an increased heat absorption rate. Besides that, Small blood volume relative to body size which limits the potential for heat conductivity and results in higher heat accumulation and low sweating levels which reduce the potential for heat dissipation through sweat evaporation. For children, trapping in a closed car is a significant risk factor for death during hot weather, where death will occur within a few hours . Additionally, due to climate change, the number of deaths from heat stroke has been reported to increase. By the 2050s, heat-stroke-related deaths are bound to grow by almost 2.5 times the current annual level of about 2000 deaths. The project aims to develop a reliable system for alerting parents who mistakenly leave their children in a car seat inside a vehicle using Node MCU Esp8266 via the Telegram Messenger application.

1.5 OBJECTIVE OF PROJECT

The objective of the Child Safety in Car project is to enhance the protection and well-being of children while traveling in vehicles by developing a comprehensive system that focuses on safety, awareness, and technology integration. The project aims to ensure the correct installation of child safety seats, possibly through sensors or alerts, to notify caregivers if the seat is improperly installed.

It also seeks to integrate advanced child restraint systems, such as smart car seats with real-time monitoring capabilities, to track the child's position and harness tightness. Additionally, the project focuses on raising awareness about proper child safety seat use and encourages the adoption of rear-facing seating for infants and toddlers. The development of advanced vehicle safety features like automatic emergency braking and child presence detection systems is another key objective, aiming to reduce risks such as leaving children behind in the car. Moreover, the project aims to work with automobile manufacturers to incorporate child-friendly features into vehicle design, improving overall safety. Ultimately, the goal is to minimize the risk of injury or death in vehicle accidents by enhancing vehicle and seat safety, providing real-time alerts for caregivers, and creating a safer travel environment for children.

CHAPTER-2

LITERATURE SURVEY

The development of child safety alert systems in cars has become a crucial area of research and innovation, driven by the increasing need to prevent tragic accidents involving children accidentally left behind in vehicles. Historically, many children have died from heatstroke after being unintentionally left inside hot cars, leading to heightened awareness and calls for better safety measures. Researchers have focused on integrating advanced technologies such as sensor-based monitoring, communication systems, and IoT solutions to address this issue. Early solutions primarily relied on weight sensors and infrared sensors placed in car seats to detect a child's presence and trigger an alert when the vehicle is turned off. For instance, systems utilizing ultrasonic sensors can detect movement and body heat, while infrared sensors track temperature changes associated with the presence of a child.

Another promising solution involves integrating mobile connectivity, where car systems send real-time alerts to a smartphone, notifying the owner if a child has been left behind in the vehicle. Such systems can leverage IoT technology to communicate with a mobile app or even notify emergency contacts via text messages, making the car owner aware of the potential risk. Additionally, integration with seat belt sensors and airbag systems has been explored, as these sensors can continuously monitor whether a child is properly seated and if any adjustments are required. However, despite these advancements, several challenges remain in perfecting child safety alert systems. These challenges include minimizing false positives and false negatives, which occur when sensors either incorrectly detect an object as a child or fail to recognize an actual child in the seat. Moreover, ensuring that these systems operate with low power consumption, especially when the vehicle is turned off, remains a key hurdle.

On top of that, the integration of such systems into existing cars, particularly older models, can be costly and technically challenging. Nevertheless, regulatory support is growing, with mandates such as the Children's Safety and Child Booster Seat Technology (SCS) Act of 2020 pushing manufacturers to adopt these systems as standard features. The future of child safety alert systems lies in the integration of artificial intelligence for enhanced detection accuracy, the development of wearable systems for children that directly interact with the vehicle's onboard systems, and the adaptation of these technologies in autonomous vehicles to ensure that child safety is never compromised, even in self-driving cars. With continued advancements in these areas, child safety alert systems are expected to become ubiquitous, saving lives and reducing the risks associated with leaving children unattended in vehicles.

The development of child safety alert systems in cars has evolved significantly over the years, driven by technological advancements and growing concerns about the safety of children in vehicles. The issue of children being unintentionally left behind in cars is not only a widespread safety concern but also a cause of many preventable deaths, primarily due to heatstroke. According to studies, many of these fatalities occur because a child is left alone in a car for just a short period, often while the driver is distracted or forgets about the child. This has spurred extensive research into automated systems that can detect a child's presence in a vehicle and alert the driver, even if they forget to check the back seat. Early systems focused on sensors like weight sensors, which can detect when a child is sitting in a car seat. These sensors send signals to the car's onboard system, triggering an audible or visual alert when the vehicle is turned off, signaling the presence of a child in the back seat. Infrared sensors have also been used to detect heat signatures, allowing systems to sense when a child's body heat is detected, even if the child is not moving. More recently, ultrasonic sensors have been integrated into these systems to enhance detection accuracy. These sensors can be installed in car seats to track the presence of children, detecting even small movements, thus ensuring timely alerts.

Along with these sensor-based systems, significant progress has been made in the integration of communication technologies, primarily leveraging IoT (Internet of Things) to provide an added layer of safety. Modern systems utilize connectivity between the car and a mobile app, enabling notifications to be sent directly to the car owner's smartphone, alerting them if a child has been left behind. Some systems also include emergency features, such as notifying emergency contacts or sending out SMS alerts to ensure that the child's safety is prioritized. The integration of smartphones and IoT in these systems is beneficial because it provides real-time communication, even when the driver is a significant distance away from the vehicle. As a result, parents or guardians can be instantly reminded to check the backseat before leaving the car, significantly reducing the risk of accidental child entrapment.

Airbag sensors and seatbelt monitoring systems have also been explored as complementary components in child safety technologies. By continuously tracking the weight and position of passengers, these systems can detect if a child is seated improperly or if a child is absent from the seat altogether. The technology uses pressure sensors to monitor the distribution of weight in the seat, helping the system identify whether a child's safety is compromised or if the seatbelt is incorrectly fastened. This combination of various sensor technologies ensures a more comprehensive solution to child safety in vehicles, as it accounts for different types of accidents and risky situations.

The implementation of regulations is another driving force behind the development of these technologies. In the United States, the Children's Safety and Child Booster Seat Technology (SCS) Act of 2020 mandates that all vehicles incorporate technologies to prevent children from being left in cars, pushing manufacturers to adopt safety systems more rapidly. Similarly, the European Union is also exploring similar regulations to standardize child safety technologies in all vehicles, making them a norm rather than an exception. As a result, car manufacturers are under increasing pressure to incorporate these systems into their designs, and many have started offering them as standard features in newer vehicle models.

2.1 EXISTING SYSTEM

The existing systems designed to prevent vehicular heatstroke in children primarily rely on manual methods, basic alarm systems, and limited technological solutions. Many parents depend on reminders, such as placing essential personal items (like bags or phones) in the backseat, to ensure they check for their child before leaving the vehicle. Some cars are equipped with basic alarm systems that trigger audio alerts when the car is locked with a child present.

Additionally, certain car seats are fitted with weight sensors that detect a child's presence and provide alerts. However, these systems are often limited in scope and effectiveness. Alerts are typically confined to the vehicle's vicinity, making them ineffective if the caregiver has already left the area. Furthermore, many current solutions lack GPS integration to provide real-time location data or remote notifications, which are critical in emergencies. While some smartphone apps attempt to address these gaps, they often depend on the user's interaction or proximity to the vehicle. Overall, existing systems are either too reliant on human attention or offer insufficient technological integration, leaving significant room for improvement in ensuring child safety in vehicles.

The integration of weight sensors in some car seats represents a step forward, allowing for the detection of a child's presence and triggering an alert within the car. However, this technology too has its limitations. Often, these alerts are confined solely to the immediate area of the vehicle, which poses a problem in situations where the caregiver is not in close proximity. In addition, the system's effectiveness can be compromised if a child's presence is not correctly detected, especially if the child is not seated in a typical manner or is not exerting enough pressure on the sensor.

Moreover, many of the current systems are not universally available or integrated across all vehicle models, particularly older ones. Retrofitting existing cars with these technologies can be costly and often impractical, leaving many vehicles without effective child safety features. While some vehicle manufacturers are beginning to include more sophisticated systems as standard features in newer models, the widespread adoption of such safety measures is still far from complete. As a result, many caregivers still rely on basic, manual solutions that are often insufficient to address the full scope of child safety risks in vehicles.

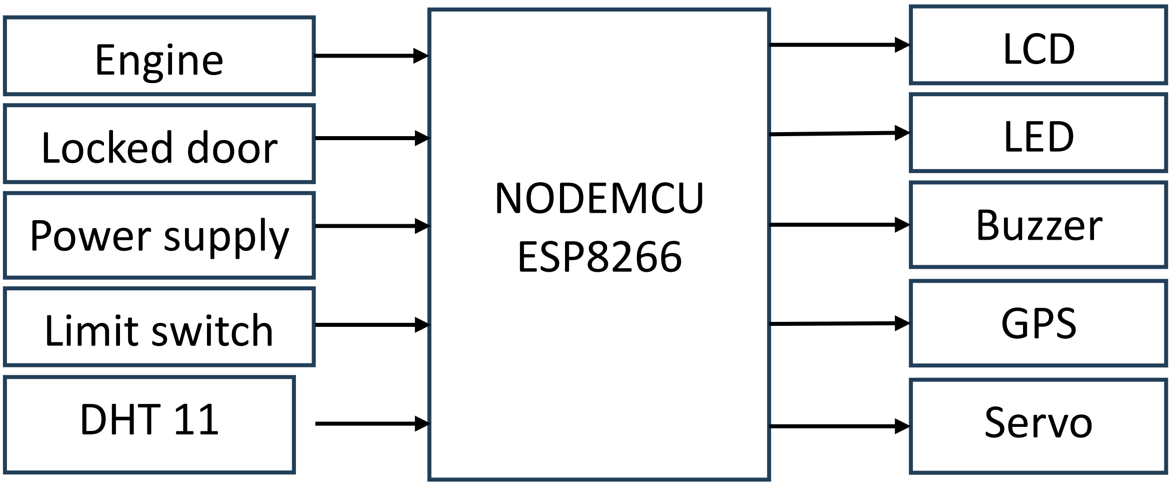

Fig 2.1: Existing Method

2.2 PROPOSED SYSTEMS

This section discusses the process for the "The Development of Car Seat Alert System through Telegram Application". For more information on the idea of the project, a flowchart and block diagram are used. This consists of two main sections which will be presented in this chapter which are hardware and software implementation. The DHT 11 temperature sensor and limit switch are the input part in the process along with the door lock and engine status switch. The temperature sensor will sense the closed vehicle temperature and the limit switch would detect the attendance of the baby.

This input output voltage will send to Node MCU Esp8266 micro controller and with the code that has been implanted inside the micro controller this the output part will be converted to the LCD display that will show the baby’s presence in the car seat while once the temperature is in danger level, the servo will roll the window down. Apart from that, LED willight up along with the buzzer which produces a continuous beep sound to alert the parents to the baby still inside the vehicle.

The function of Nod emcu ESP8266 and GPS module, and warning text message with user coordinates will be sent to the registered person, and half of the car window will be rolled down by the servo motor to reduce the closed car temperature so that the heatstroke does not occur to the baby.

2.3 COMMUNICATION INTRODUCTION

Many embedded systems have substantially different design constraints than desktop computing applications. No single characterization applies to the diverse spectrum of embedded systems. However, some combination of cost pressure, long life-cycle, real-time requirements, reliability requirements, and design culture dysfunction can make it difficult to be successful applying traditional computer design methodologies and tools to embedded applications. There is currently little tool support for expanding embedded computer design to the scope of holistic embedded system design. However, knowing the strengths and weaknesses of current approaches can set expectations appropriately, identify risk areas to tool adopters, and suggest ways in which tool builders can meet industrial needs..

Communication is the process of exchanging information, ideas, or messages between individuals, groups, or systems. It is fundamental to human interaction and plays a pivotal role in various aspects of life, ranging from personal relationships to business operations, scientific advancements, and even global interactions. Communication can be verbal, non-verbal, written, or visual, and it occurs through multiple channels, such as face-to-face conversations, phone calls, emails, social media, or even through technology-enabled systems.

In the context of technology, communication systems refer to the infrastructure and tools that facilitate the transmission of data, voice, or multimedia content between devices or people. These systems are essential in fields like telecommunications, broadcasting, and the internet, where large amounts of information need to be transmitted efficiently and securely over distances. The development of communication technologies has evolved dramatically over the years, from early forms like smoke signals and messenger pigeons to the modern era of fiber optics, 5G networks, and satellite communication.

In today's world, effective communication is increasingly driven by digital technologies, enabling real-time interaction, information sharing, and global connectivity. With the advent of technologies like cloud computing, artificial intelligence (AI), and IoT (Internet of Things), communication systems have become more sophisticated, allowing for instantaneous data transfer and the automation of various processes. These advancements have revolutionized industries such as healthcare, education, and business, fostering greater collaboration and efficiency.

As we move forward, the future of communication systems will likely continue to be shaped by advancements in 5G and beyond, quantum communication, and integrated smart systems, which promise even faster, more secure, and more interconnected forms of communication. Ultimately, communication remains a cornerstone of human interaction and technological progress, constantly evolving to meet the demands of a rapidly changing world.

However, as communication systems become more advanced, new challenges emerge. Issues such as privacy concerns, data security, and the digital divide—which refers to the disparity in access to technology and the internet—remain significant challenges that must be addressed. The increasing reliance on digital communication systems also brings concerns about cybersecurity threats and misinformation, making it crucial to develop more secure, reliable, and ethical communication frameworks.

The future of communication holds exciting possibilities. Advancements in quantum communication could lead to unhackable communication channels, promising more secure exchanges of sensitive information. Augmented reality (AR) and virtual reality (VR) technologies may create immersive communication experiences, transforming how people interact with information and each other. Blockchain technology could play a key role in ensuring the authenticity and security of digital communications, preventing fraud and manipulation.

2.3.1 Specification

The specification of communication refers to the technical details that define how data is transmitted and received. It includes the communication medium (wired or wireless), data rate (speed of transmission), and modulation techniques for encoding data. Protocols like TCP/IP establish rules for data transfer, while error detection methods ensure reliability. Latency measures transmission delay, and security ensures data integrity through encryption. Addressing and routing ensure data reaches the correct destination, and signal strength impacts communication quality. These specifications ensure efficient and secure data exchange in communication systems.

2.3.2 System-Synthesis

This process involves selecting the appropriate technologies, protocols, and methodologies to meet the requirements of the system, such as data rate, security, reliability, and cost efficiency. It encompasses both the hardware and software aspects of communication, as well as the interaction between them to ensure smooth data transmission and reception.

2.3.3 Implementation-Synthesis

It refers to the process of translating the designed communication system into a functioning system by integrating and deploying the chosen components, technologies, and protocols. This stage involves the practical application of system specifications and architecture into hardware and software solutions that ensure real-world functionality, reliability, and efficiency. It also involves optimization and tuning to meet the specific performance and operational goals of the communication system.

2.3.4 Prototyping

Prototyping refers to the process of creating a preliminary model or prototype of a communication system to test and validate its design, features, and functionality before full-scale implementation. Prototyping helps identify potential issues, optimize system performance, and ensure that the final system meets its objectives. In communication systems, prototyping is crucial as it allows designers to experiment with different technologies, protocols, and configurations to refine the system and reduce risks.

APPLICATIONS

Applications of communication are vast and play a critical role in numerous fields, ranging from personal interactions to complex industrial systems. Communication technologies facilitate the exchange of information, making processes more efficient, enabling real-time decision-making, and enhancing global connectivity. In personal life, communication is essential for social interaction, education, and entertainment, with tools like smartphones, social media platforms, and messaging apps. In business, communication enables collaboration, customer service, marketing, and logistics, driving productivity and growth.

In the healthcare sector, communication systems enable telemedicine, allowing patients and doctors to communicate remotely, providing timely care and advice. In transportation, communication networks facilitate real-time tracking of vehicles, enabling efficient traffic management, safety features, and navigation systems. For emergency services, communication systems are vital for quick coordination during natural disasters or accidents, where rapid information exchange can save lives.

In military applications, communication is crucial for operations, strategic planning, and surveillance. IoT (Internet of Things) systems rely on communication networks to connect smart devices, enabling automation and real-time data analysis across homes, industries, and cities. Communication also plays a pivotal role in finance, where secure transactions, real-time stock market updates, and banking services rely on robust communication networks.

Overall, communication systems are integral to modern life, enhancing every aspect of society by making information exchange faster, more accessible, and more reliable. They are foundational in driving advancements in technology, healthcare, education, and many other fields.

- **Telecommunication**: Enables voice calls, video conferencing, and instant messaging via mobile networks (4G, 5G), landlines, and internet-based platforms like VoIP.

- **Internet of Things (IoT)**: Facilitates communication between smart devices (sensors, home automation systems) to collect and share data for smart homes, healthcare, and industrial automation.

- **Healthcare**: Enables telemedicine, remote patient monitoring, and communication between medical professionals for timely diagnosis, patient care, and emergency services.

- **Military and Defense**: Communication technologies enable secure data exchange for operational coordination, surveillance, and strategic planning.
- **Business and Enterprise**: Supports internal communication, customer service, marketing, collaboration tools (email, instant messaging, video calls), and supply chain management.
- **Emergency Services**: Vital for coordinating rescue operations, disaster management, and providing emergency response through mobile networks, GPS, and communication radios.

2.3.5 Why Communication ?

Communication is a fundamental aspect enabling the transmission and reception of data across various channels and devices. It forms the backbone of modern technological advancements, facilitating seamless information exchange through wired and wireless networks. Traditional communication systems relied on analog signals, such as AM and FM radio transmissions, but with the rise of digital technologies, communication has become more efficient, secure, and high-speed. Modern communication systems utilize fiber optics, satellite communication, wireless networks (Wi-Fi, Bluetooth, 5G), and embedded systems, making global connectivity possible. Engineers in the field of ECE work on designing and improving communication protocols, modulation techniques, and network security to enhance data transmission reliability and efficiency.

Wireless communication, a significant part of ECE, includes mobile networks, satellite systems, radar technology, and IoT-based communication, which play a crucial role in industries like healthcare, transportation, military, and smart cities. The integration of 5G technology and AI-driven networks has revolutionized the communication sector, enabling ultra-fast data transmission with minimal latency, supporting autonomous systems, smart homes, and industrial automation. Optical fiber communication has further improved internet speeds and reliability, making long-distance communication seamless and interference-free. Moreover, advancements in communication protocols (TCP/IP, VoIP, and encryption methods) ensure secure and efficient data exchange in real-time applications.

The applications of communication in ECE extend across various domains, including telecommunications, broadcasting, remote sensing, space exploration, industrial automation, and telemedicine. In the healthcare sector, wireless biomedical sensors and telemedicine have improved patient monitoring and remote diagnosis. Similarly, in defense and military applications, radar systems and secure satellite communication play a vital role in national security and surveillance. With continuous advancements in AI, IoT, and quantum communication, the future of communication in ECE is evolving towards more intelligent, efficient, and high-speed networks, shaping the next generation of global connectivity and digital transformation.

In the early days, communication systems were primarily analog, utilizing technologies such as Amplitude Modulation (AM) and Frequency Modulation (FM) for radio and television broadcasting. However, with the rise of digital communication, modern systems now employ advanced techniques such as Pulse Code Modulation (PCM), Quadrature Amplitude Modulation (QAM), and Orthogonal Frequency Division Multiplexing (OFDM) to improve data transmission speed, accuracy, and efficiency. Digital communication offers higher reliability, better noise resistance, and greater bandwidth utilization, making it the preferred choice for modern applications. The integration of optical fiber communication has further revolutionized data transfer by offering high-speed, low-loss transmission over long distances, forming the backbone of today's internet infrastructure.

Wireless communication has become an integral part of modern technology, enabling real-time connectivity through various standards like Wi-Fi, Bluetooth, Zigbee, LTE, and 5G networks. These technologies have enhanced mobile communication, home automation, industrial control systems, and smart city applications. The latest advancements in 5G technology provide ultra-low latency and high-speed data transmission, supporting emerging applications such as autonomous vehicles, augmented reality (AR), virtual reality (VR), and remote robotic surgeries. Moreover, satellite communication plays a crucial role in global connectivity, GPS navigation, weather monitoring, and defense operations, ensuring reliable long-range communication without geographical limitations.

Another major area in communication engineering is IoT-based communication, where smart devices interact over the internet to collect and share data in real time. This technology is widely used in smart homes, healthcare monitoring systems, industrial automation, and smart agriculture. IoT-enabled communication systems help in predictive maintenance, real-time monitoring, and decision-making, improving efficiency and reducing operational costs in various industries. Additionally, radar and sonar communication systems are essential in military, aviation, and maritime applications, aiding in navigation, surveillance, and object detection.

To ensure smooth and secure data exchange, communication networks utilize various protocols such as TCP/IP (Transmission Control Protocol/Internet Protocol), HTTP, FTP, and VoIP (Voice over Internet Protocol). These protocols help in data transmission, encryption, error detection, and recovery, making modern communication systems more reliable and secure. In critical applications like banking, cybersecurity, and defense, encryption techniques like AES (Advanced Encryption Standard) and RSA (Rivest-Shamir-Adleman) are employed to protect sensitive information from cyber threats.

The applications of communication can extend to almost every sector, including telemedicine, industrial automation, space exploration, remote sensing, broadcasting, education, and emergency response systems. In healthcare, wireless biomedical sensors and telemedicine platforms enable remote patient monitoring, improving medical access and reducing healthcare costs. In transportation, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication systems enhance road safety, enabling intelligent traffic management and autonomous driving. Similarly, in defense and aerospace, secure satellite communication and radar systems play a vital role in national security, surveillance, and strategic military operations.

With continuous advancements in AI-driven communication networks, quantum communication, and 6G research, the future of communication engineering is set to become even more dynamic and intelligent. AI-based network optimization, real-time data analytics, and automated signal processing are improving efficiency and reducing latency in communication systems. Quantum communication, which leverages the principles of quantum mechanics, aims to revolutionize secure data transmission by making communication networks virtually hack-proof. The development of 6G technology is expected to push the boundaries of ultra-fast, ultra-reliable wireless communication, enabling futuristic applications like holographic communication, brain-computer interfaces, and seamless machine-to-machine interaction.

In conclusion, communication it is a rapidly evolving field that underpins modern technological advancements and global connectivity. From traditional wired systems to cutting-edge wireless communication, the field continues to expand, making our world more interconnected than ever before. With emerging technologies like 5G, IoT, AI, and quantum communication, the future of communication is poised to redefine the way humans and machines interact, leading to smarter, faster, and more secure global communication networks.

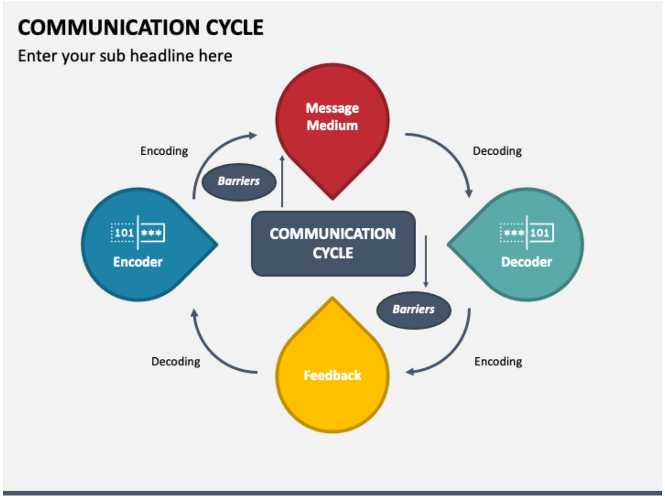

Fig 2.2: Communication Development Life Cycle

As technology continues to advance, communication will remain at the core of human interaction and industrial progress. The ongoing research and implementation of secure, high-speed, and intelligent communication networks will shape the future of global connectivity, making it more efficient, resilient, and adaptive to the growing demands of an interconnected world. Ultimately, communication is not just about transmitting data—it is about bridging gaps, fostering collaboration, and driving innovation, ensuring that societies and industries continue to evolve in an increasingly digital era.

2.4 DESIGN APPROACHES

The design of communication systems is a structured process that ensures reliable, efficient, and secure data transmission across different mediums. In Electronics and Communication Engineering (ECE), designing a communication system involves multiple stages, including requirements analysis, signal processing, modulation techniques, transmission medium selection, error detection, security implementation, and system optimization. The primary objective is to develop a communication network that provides seamless and high-speed connectivity with minimal data loss and interference.

The process begins with an in-depth requirements analysis, where factors like bandwidth, data rate, transmission range, power consumption, and security protocols are considered based on the application's needs. The next crucial step is selecting an appropriate modulation technique, which helps encode the information signal for transmission while ensuring minimal distortion and noise interference. For instance, traditional analog modulation techniques like Amplitude Modulation (AM) and Frequency Modulation (FM) were widely used in early radio communication, while modern digital communication systems rely on Phase Shift Keying (PSK), Quadrature Amplitude Modulation (QAM), and Orthogonal Frequency Division Multiplexing (OFDM), which offer higher efficiency and better resistance of interference.

COMMUNICATION SYSTEM WITH ARDUINO

Arduino is a widely used open-source platform for building communication systems due to its simplicity, affordability, and compatibility with various communication modules. It enables real-time data transmission between electronic devices, sensors, and networks using different communication protocols such as serial communication (UART), wireless communication (Wi-Fi, Bluetooth, RF, LoRa), and wired communication (I2C, SPI, Ethernet).

Arduino is a versatile platform that supports a variety of communication modules, enabling data transmission over different channels such as wireless, wired, short-range, and long-range communication. These modules allow Arduino to interact with sensors, control devices remotely, and communicate with other systems. Below are some commonly used communication modules for Arduino:

1. **Serial Communication (UART):**Serial communication allows data transmission over a two-wire interface (TX and RX pins). It is the most basic form of communication where data is transferred byte by byte.

2. **Bluetooth Communication:**Bluetooth modules allow short-range wireless communication between Arduino and other Bluetooth-enabled devices like smartphones, tablets, or PCs.

3. **Wi-Fi Communication:**These modules enable Arduino to connect to Wi-Fi networks and transmit or receive data over the internet. The ESP8266 and ESP32 are both Wi-Fi-enabled microcontrollers with sufficient processing power for handling complex tasks and IoT applications.

4. **GSM/GPRS Communication:**GSM modules provide cellular communication capabilities, allowing Arduino to send SMS messages, make phone calls, or access the internet via GPRS

Overview of Communication Systems in Safety Applications

Communication systems are integral to safety applications, especially in domains like automotive safety, healthcare, industrial safety, and emergency response. These systems enable real-time information exchange between different entities, allowing quick response and preventive measures in critical situations. The key objective of communication systems in safety applications is to provide timely alerts, monitoring, and control mechanisms that ensure human lives and property are safeguarded.

Types of Communication Systems Used in Safety Applications

1. Wired Communication Systems: Traditional safety applications used wired communication systems (e.g., phone lines, fiber optics) to transmit information. While these systems are stable and secure, they may lack flexibility and require physical infrastructure.

2. Wireless Communication Systems: The modern approach to safety systems has shifted toward wireless communication technologies for their flexibility, scalability, and ability to function over large distances. Wireless communication plays a vital role in monitoring safety situations where physical cables are impractical. Examples include

3. Bluetooth: Used in personal safety devices (e.g., wearable safety alerts).

4. Wi-Fi: Used in home security systems for video surveillance and emergency alerts.

  1. **Zigbee and LoRa**: Typically used in low-power, long-range sensor-based applications, such as environmental monitoring or smart building systems.

  2. **GSM and 4G/5G Networks**: Allow communication between remote safety devices (e.g., fire alarms, vehicle safety systems) and emergency response services.

Communication Components in Safety Systems

Communication systems in safety applications are made up of several components that work in harmony to ensure effective alerts and real-time monitoring:

1. **Sensors**: Various types of sensors, such as motion sensors, temperature sensors, gas detectors, and CO2 sensors, are deployed to monitor the environment or specific objects (e.g., children left in cars, fire hazards, hazardous gas leakage). These sensors collect data and send it through communication modules to a central processing unit.

2. **Transmitters and Receivers**: Once sensors detect an anomaly (e.g., heat, motion), they send signals to a transmitter, which conveys the data wirelessly to a receiver. The receiver is typically connected to an alert system or a mobile application that notifies users about the situation.

3. Central Processing Unit: A central processor or microcontroller (e.g., Arduino, Raspberry Pi) is used to manage sensor data, process it, and trigger alerts when specific thresholds are crossed. This could involve sending notifications to emergency contacts or alerting local authorities.

Real-Time Communication for Safety Applications

In safety-critical situations, real-time communication is essential. These systems must be capable of transmitting data instantly and reliably to prevent any delay in response

1. **Emergency Alert Systems:** In applications such as fire safety or car safety, the ability to send instant alerts is crucial. For example, if a child is left behind in a car, real-time communication via GSM or Wi-Fi ensures the parent or emergency contacts are notified immediately.

2. Automated Emergency Systems: In more advanced setups, real-time communication can trigger automated emergency responses, such as calling emergency services or notifying caregivers of an urgent situation.

Sensor Integration For Child Safety

Sensor integration is a vital aspect of child safety systems in vehicles, as it enhances the ability to detect potentially hazardous situations and trigger appropriate alerts. These sensors help monitor various environmental factors and the presence of the child inside the vehicle, ensuring the system functions effectively and can respond to emergencies. The integration of multiple sensors allows for a more robust, accurate, and efficient safety system that can provide real-time data to prevent accidents, such as heatstroke, or protect children from being left behind in a vehicle.

Types of Sensors Used in Child Safety Systems

1. Presence Detection Sensors: Presence detection is one of the most crucial features of a child safety system. Several sensor types are commonly used to detect the presence of a child inside the vehicle

2. Temperature and Humidity Sensors: One of the major risks associated with leaving a child unattended in a vehicle is heatstroke. Heatstroke can occur rapidly in a car, especially in hot weather. Therefore, temperature sensors are essential in child safety systems

3. **Motion Sensors:**Motion sensors are useful for detecting any movement inside the vehicle, including the movement of a child.

4. **Camera Sensors:**Camera sensors, often integrated with image processing algorithms, can enhance child safety by allowing visual monitoring of the child's condition and the environment inside the car.

5. **Pressure Sensors for Seat Belts:**Pressure sensors can be used to monitor whether a child is securely buckled into the car seat. These sensors can be embedded into the seat or the seatbelt and can detect when the seatbelt is fastened properly or when a child attempts to unbuckle themselves.

Integration of Sensors into the Child Safety System

To create an effective child safety alert system, these sensors need to be integrated into a unified communication platform. The data collected from the various sensors (weight, motion, temperature, humidity, pressure) must be processed and analyzed to trigger appropriate actions. The integration involves:

1. **Sensor Fusion**:Combining data from different sensors to provide a more accurate and reliable system. For example, the system could use weight sensors in combination with temperature sensors to detect when a child is left in the car under dangerous conditions (e.g., high temperature and child presence).

2. **Microcontroller Integration**:A microcontroller (e.g., Arduino, Raspberry Pi) processes sensor data and triggers alerts when thresholds are exceeded. It can send real-

time information via GSM modules for SMS alerts or Wi-Fi modules for cloud-based monitoring.

3. Alert Mechanisms:When dangerous conditions are detected (e.g., child left behind or high temperature), the system can issue alerts through multiple channels, such as SMS messages, mobile app notifications, or emergency calls to caregivers, emergency services, or authorities.

Benefits of Sensor Integration in Child Safety Systems

1. Early Detection: Sensors can detect critical conditions (e.g., heat, child presence) at an early stage, allowing for immediate action and preventing harm.

2. Reliability: The use of multiple sensors ensures redundancy, meaning the system is less likely to fail or provide false alerts.

3. **Real-Time Monitoring**: Continuous sensor data allows caregivers to monitor the situation in real-time and make informed decisions in emergencies.

4. **Preventative Measures**: With sensors integrated into the system, risks such as heatstroke, unbuckled seatbelts, or forgotten children can be identified and addressed proactively, providing peace of mind to caregivers.

Challenges In Communication System

1. **Signal Reliability**: In many safety-critical systems, communication reliability is paramount. Interference, environmental factors (e.g., poor weather conditions), or network congestion can affect the transmission of crucial safety information. Thus, technologies like redundancy and error detection/correction are essential.

2. **Power Consumption:** Many safety devices, especially wearable devices or those in remote locations, run on battery power. Therefore, communication technologies used in safety systems must be energy-efficient to ensure long operational times without frequent recharging.

3. **Security**: Ensuring secure communication is a significant concern in safety

applications. Systems that send sensitive data (like location or health information) must implement encryption and authentication protocols to protect user privacy and prevent unauthorized access.

CHAPTER-3

HARDWARE REQUIREMENTS

3.1 HARDWARE

The development of a Child Safety Alert System in a car requires the integration of various hardware components to ensure real-time monitoring and response to potential safety hazards. A central microcontroller, such as an Arduino or Raspberry Pi, acts as the core of the system, processing data from multiple sensors and controlling other components. Key sensors include weight sensors (such as load cells) to detect the presence of a child in the seat, temperature and humidity sensors to monitor the vehicle's internal climate and prevent heatstroke, and motion sensors to detect any movement, ensuring that the child remains securely in place. Additionally, a GPS module tracks the vehicle's location and can send alerts if the vehicle is moving without the child, while a GSM module facilitates communication, sending SMS or making emergency calls in case of an unsafe situation. Communication is further enhanced by using Wi-Fi or Bluetooth modules, enabling remote monitoring via mobile apps. The system also includes a buzzer for audible alerts and a relay that can trigger external devices like the car's alarm system or door locks in an emergency. Together, these components create a comprehensive and reliable safety solution for children in vehicles, ensuring rapid detection and response to potentially life-threatening situations.

3.1.1 ESP32 Micro Controller

The ESP32 is a highly integrated micro controller designed to meet the demands of modern IoT applications and embedded systems. Manufactured by Espressif Systems, it combines high performance, versatility, and energy efficiency, making it a go-to solution for developers bbAt its core, the ESP32 features a dual-core Tensilica Xtensa LX6 processor running at up to 240 MHz, capable of handling multitasking and computationally intensive applications. Additionally, it includes a low-power co-processor for tasks like ADC measurements and GPIO monitoring in deep sleep modes, enabling efficient power usage.

The ESP32's connectivity options are a key highlight, with dual-mode Bluetooth (Classic and BLE) and support for 802.11 b/g/n Wi-Fi, offering robust and flexible wireless communication. This makes it ideal for smart devices, wearable technology, and industrial automation where wireless communication is critical. Security features such as Secure Boot, Flash Encryption, and crypto graphic hardware acceleration ensure data protection and device integrity, a crucial factor for IoT deployments.

In terms of hardware, the ESP32 supports 34 programmable GPIO pins, which can be configured for multiple peripheral interfaces, including UART, SPI, I2C, I2S, ADC, DAC, PWM, and touch sensors. With up to 16 MB of external flash memory support, it accommodates complex firmware and large scale projects. Its integrated temperature sensor, Hall sensor, and capacitive touch sensors further enhance its functionality, allowing developers to build innovative and feature-rich solutions.

The ESP32 also supports various power modes, including deep sleep and hibernation, making it suitable for battery-powered devices. Its modular design and compatibility with popular development environments like Arduino IDE, Micro-Python, and ESP-IDF (Espressif IoT Development Framework) provide an accessible development experience for both beginners and professionals.

The ESP32 is a feature-rich, low-cost microcontroller from Espressif Systems that combines high performance processing, advanced connectivity options, and low power consumption. It is widely used in applications like IoT (Internet of Things), smart devices, automation, robotics, and embedded systems. Here's an in-depth look at its features and architecture.

The ESP32 also emphasizes security with features like Secure Boot, Flash Encryption, and hardware acceleration for cryptographic algorithms, ensuring secure communication and data protection. It supports multiple power-saving modes, including deep sleep and hibernation, making it ideal for battery-operated devices. Development is streamlined with support for ESP-IDF (the official development framework), Arduino IDE, Micro Python, and PlatformIO, providing flexibility for developers. Its broad applications span smart home systems, wearable technology, industrial automation, robotics, and edge computing, making the ESP32 a cornerstone in the world of IoT and embedded systems.

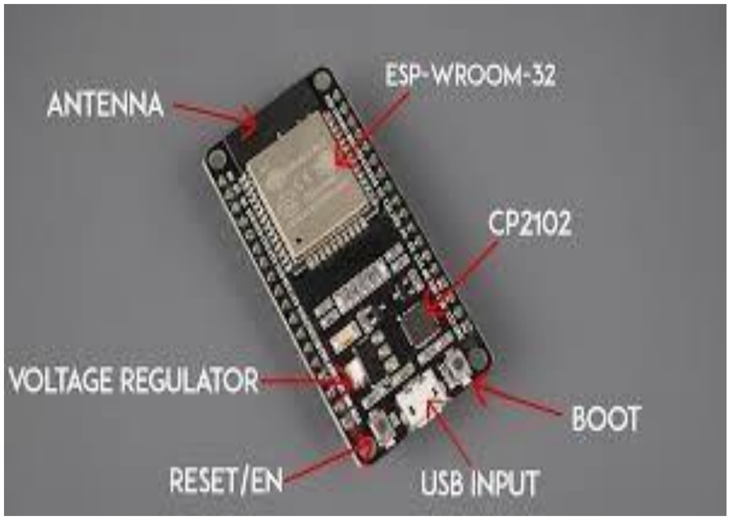

Fig 3.1: ESP32 micro controller

The ESP32 is a highly versatile micro controller developed by Espressif Systems, designed for IoT and embedded applications. It features a dual-core Tensilica Xtensa LX6 processor, running at up to 240 MHz, along with an ultra-low-power co-processor for energy- efficient tasks during deep sleep modes. Integrated Wi-Fi (802.11 b/g/n) and Bluetooth (Classic and BLE) provide robust wireless communication, supporting modes like Station,Access Point, and Mesh networking. The ESP32 is equipped with 34 GPIO pins configurable for multiple peripherals, including ADC, DAC, UART, SPI, I2C, PWM, and capacitive touch sensors. With 520 KB of SRAM, 448 KB of ROM, and support for up to 16 MB of external Advanced security features like Secure Boot, Flash Encryption, and cryptographic hardware make it suitable for secure IoT deployments. Its compatibility with development environments like ESP IDF, Arduino IDE, and Micro Python further enhances its accessibility, making it ideal for smart home devices, wearables, robotics, and automation systems.

The ESP32 is a robust micro controller developed by Espressif Systems, designed for IoT, automation, and embedded applications. It features a dual-core Tensilica Xtensa LX6 processor capable of running at up to 240 MHz, delivering excellent multitasking performance. The micro controller integrates 520 KB of SRAM, 448 KB of ROM, and supports external SPI flash of up to 16 MB, with some models offering up to 8 MB of PSRAM for resource-heavy applications like video processing. Connectivity is a standout feature, with 802.11 b/g/n Wi-Fi supporting +speeds of up to 150 Mbps and multiple modes,including Station, Access Point, and Mesh Networking. It also includes Bluetooth 4.2, supporting both Classic and Low Energy modes for versatile communication.

3.1.2 Features of Esp32

- Onboard ESP32-S module, supports WiFi + Bluetooth
- OV2640 camera with flash
- Onboard TF card slot, supports up to 4G TF card for data storage
- Supports WiFi video monitoring and WiFi image upload
- Supports multi sleep modes, deep sleep current as low as 6mA
- Control interface is accessible via pin header, easy to be integrated and embedded into user products
- Comes with ESP32-CAM-MB Micro USB to serial port adapter, adapts CH340 chip, for connecting ESP32-CAN to the PC, no additional converter required.

3.1.3 Specifications

- WIFI module: ESP-32S
- Processor: ESP32-D0WD-V3
- Antenna: Onboard PCB antenna
- WiFi protocol: IEEE 802.11 b/g/n/e/i
- Bluetooth: Bluetooth 4.2 BR/EDR and BLE
- WIFI mode: Station / Soft-AP / Soft-AP+Station
- Security: WPA/WPA2/WPA2- Enterprise/WPS
- Output image format: JPEG (OV2640 support only), BMP, GRAYSCALE
- Supported TF card: up to 4G
- Peripheral interface: UART/SPI/I2C/PWM
- IO port: 9
- UART baudrate rate: default 115200bps
- Power supply: 5V
- Transmitting power:
- 802.11b: 17 ±2dBm(@11Mbps)

- 802.11g: 1 ±2dBm(@54Mbps)
- 802.11n: 13 ±2dBm(@HT20,MCS7)
- Receiving sensitivity:
- CCK,1Mbps: -90 dBm
- CCK,11Mbps: -85 dBm
- 6Mbps(1/2 BPSK): -88 dBm
- 54Mbps(3/4 64-QAM): -70 dBm
- HT20,MCS7(65Mbps, 72.2Mbps): -67 dB
- Power consumption:
- Flash off: 180mA@5V
- Flash on and brightness max: 310mA@5V
- Deep-Sleep: as low as 6mA@5V
- Modern-Sleep: as low as 20mA@5V
- Light-Sleep: as low as 6.7mA@5V
- Operating temperature: -20 ℃ ~ 85 ℃
- Storage environment: -40 ℃ ~ 90 ℃, <90%RH

3.1.4 Applications of Esp32

The ESP32-CAM suit for IOT applications such as:

- Smart home devices image upload
- Wireless monitoring
- Intelligent agriculture
- QR wireless identification
- facial recognition

Fig.3.2: Esp32 cam Internal structure

The ESP32 microcontroller is widely used in various applications due to its high performance, low power consumption, and built-in Wi-Fi and Bluetooth connectivity. One of its primary applications is in Internet of Things (IoT) projects, where it enables smart home automation systems, industrial automation, and remote monitoring of devices. It is commonly used in smart security systems, allowing real-time surveillance and alerts through Wi-Fi-connected cameras and sensors. The ESP32 is also popular in wearable technology due to its low power consumption, making it ideal for fitness trackers and health monitoring devices. In robotics and automation, the ESP32 is used to control motors, sensors, and wireless communication between robots and other systems. It also plays a significant role in environmental monitoring, where it collects and transmits data on temperature, humidity, and air quality for smart agricultural applications. Additionally, ESP32 is integrated into wireless communication systems, enabling real-time data transmission in smart meters, weather stations, and remote-controlled drones. Due to its versatility, affordability, and ease of programming, the ESP32 continues to be a preferred choice for developers in a wide range of embedded systems and smart technology applications.Another significant application of ESP32 is in wireless sensor networks, where it enables seamless communication between multiple sensors for data collection and analysis in environmental monitoring systems. It is also widely used in edge computing, where real-time data processing is performed at the source rather than being sent to the cloud, reducing latency and improving efficiency

Antenna Selection

- Change the position of the following resistor to select the antenna to be used:
- The resistor is at position ① by default and using the onboard antenna.

The gain is 2db.

- If you need to use the external antenna, please modify the resistor to position ② by yours

3.2 NODE MCU

Fig.3.3:Node Mcu

The Node MCU is an open-source IoT development board based on the ESP8266 Wi-Fi module, designed for easy integration into Internet of Things (IoT) applications. It features a low-power micro controller with built-in Wi-Fi, making it ideal for smart home automation, remote monitoring, and embedded systems. The board operates at 3.3V, with 17 GPIO pins, one ADC (analog) pin, and supports multiple communication protocols, including I2C, SPI, and UART. It comes with a USB-to-serial converter (CH340/CP2102) for easy programming via Arduino IDE, Lua, or Micro Python. Node MCU is powered through a Micro USB port (5V) or Vin (4.5V–5.5V) and supports PWM, ADC, and digital input/output functions. Its small size, low cost, and Wi-Fi capability make it a preferred choice for wireless applications, such as weather stations, smart devices, and automation systems. However, it has limitations, including a single ADC pin and 3.3V logic level compatibility. Despite this, Node MCU remains one of the most popular micro controllers for IoT development due to its ease of use, versatility, and strong community support.

One of NodeMCU’s key advantages is its versatility and ease of programming, supporting languages like C++ (Arduino IDE), Lua, and MicroPython. It comes with a built-in USB-to-serial converter (CH340G or CP2102), making it simple to connect to a computer for programming and debugging. The board is powered via a Micro USB port (5V) or through the Vin pin (4.5V–5.5V) for external power sources. It also supports deep sleep mode, significantly reducing power consumption, making it ideal for battery-powered IoT applications.

NodeMCU is widely used in smart home automation, weather monitoring, security systems, robotics, and industrial automation due to its compact size, low cost, and reliable wireless connectivity. Despite its advantages, it has some limitations, including a single ADC pin, 3.3V logic level compatibility (not directly compatible with 5V sensors), and fewer GPIO pins compared to traditional microcontrollers like Arduino Mega. However, its built-in Wi-Fi module and ease of integration with cloud services make it a preferred choice for modern wireless projects. With a strong community, extensive documentation, and numerous libraries, NodeMCU remains a powerful and cost-effective solution for IoT developers, hobbyists, and engineers looking to build innovative and connected applications.

The NodeMCU is an open-source IoT development board based on the ESP8266 Wi-Fi module, designed for easy integration of Wi-Fi connectivity into embedded systems. It features a low-power 32-bit microcontroller, built-in Wi-Fi, and GPIO (General Purpose Input/Output) pins for connecting sensors, actuators, and other electronic components. The board supports Lua scripting and Arduino IDE, making it beginner-friendly and suitable for rapid prototyping of IoT applications.

With its compact size, low cost, and efficient power consumption, NodeMCU is widely used in home automation, smart devices, and IoT-based projects. It includes an onboard USB-to-serial converter for easy programming and debugging. The combination of Wi-Fi capabilities and simple programming makes NodeMCU a popular choice for students, hobbyists, and developers working on wireless communication and automation projects.

NodeMCU Specifications:

Feature	Details
Microcontroller	ESP8266
Operating Voltage	3.3V
Input Voltage (USB)	4.5V – 5.5V
Flash Memory	4MB
SRAM	64KB
Clock Speed	80MHz (can be overclocked to 160MHz)
Wi-Fi Standard	IEEE 802.11 b/g/n
GPIO Pins	17
Analog Input	1 (ADC0, 10-bit resolution)
UART Ports	2
I2C & SPI	Yes
PWM Pins	Upto 8
USB-to-Serial	CP2102 / CH340G

Table 3.1:Nodemcu specifications

Node Mcu Pinouts &Description:

Pin Name	GPIO	Function
Vin	**-**	External 5V power input
3.3V	-	Regulated 3.3V output
GND	-	Ground
D0	GPIO16	Can be used for Wake-Up, no PWM/I2C support
D1	GPIO5	I2C (SCL), PWM, GPIO
D2	GPIO4	I2C (SDA), PWM, GPIO
D3	GPIO0	GPIO, used for boot mode
D4	GPIO2	Built-in LED (LOW = ON), PWM, GPIO
D5	GPIO14	SPI (SCK), PWM, GPIO
D6	GPIO12	SPI (MISO), PWM, GPIO
D7	GPIO13	SPI (MOSI), PWM, GPIO
D8	GPIO15	SPI (CS), PWM, GPIO
A0	ADC0	Analog input (0V - 3.3V)
RX	GPIO3	UART RX (Receive)
TX	GPIO1	UART TX (Transmit)
RST	-	Reset button (Active LOW)

Table 3.2:Nodemcu pinouts

Powering the Node MCU

1. **Through Micro USB:** 5V (Recommended for general use).
2. **Through Vin Pin:** 4.5V - 5.5V (Use an external power source).
3. **Logic Level:** 3.3V (Do NOT apply 5V directly to GPIOs!)

NodeMCU Communication Protocols

1. **UART (RX, TX):** Used for serial communication with PC or other devices.

2. **I2C (D1=SCL, D2=SDA):** Connect sensors like DHT11, OLED, MPU6050.

3. SPI (D5, D6, D7, D8): Interface with SD cards, RFID, and LCDs.

4. PWM (D1-D8): Control motors, LEDs, and servos.

Applications of NodeMCU

1. **Home Automation** – Smart switches, security cameras.

2. **IoT Projects** – Weather monitoring, remote data logging.

3. **Robotics** – Wireless robot control.\

4. Industrial Automation – Sensor-based automation, MQTT.

5. Smart Agriculture – Soil moisture monitoring.

Advantages of NodeMCU

1. Built-in Wi-Fi for IoT applications.

2. More processing power than Arduino.

3. Low power consumption for battery-powered projects.

4. Supports multiple programming languages (C++, Lua, MicroPython).

NodeMCU Limitations

1. Only one ADC pin (A0).

2. Operates at 3.3V (not 5V tolerant).

3. Limited GPIOs compared to other micro controllers.

3.3 DHT11 TEMPERATURE SENSOR

The DHT11 is a low-cost, digital temperature and humidity sensor commonly used in various electronics projects. It measures the ambient temperature and relative humidity and provides the data in a digital format. Here's a detailed overview.

Features of the DHT11 Temperature Sensor:

1. Temperature Measurement Range
2. Humidity Measurement Range
3. Output
4. Power Supply
5. Communication
6. Response Time
7. Pinout

DHT11 Temperature Sensor

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3.4 POWER SUPPLY

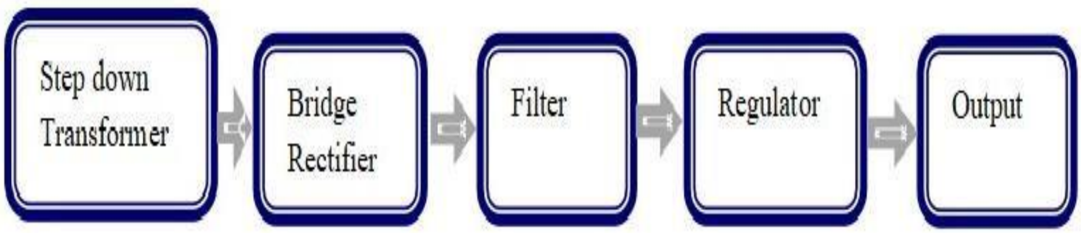


Fig 3.4:Block diagram for power supply

The input to the circuit is applied from the regulated power supply. The a.c. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating d.c voltage.

In order to get a pure d.c voltage, the output voltage from the rectifier is fed to a filter to remove any a.c components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage. The design of the power supply must account for factors such as power consumption, voltage regulation, and energy efficiency, as many embedded systems operate in environments where power resources are limited, such as in battery-powered or remote applications.

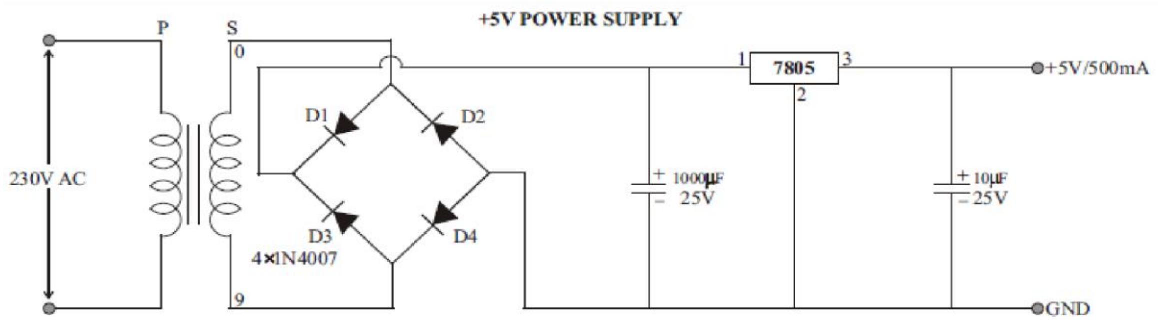


Fig 3.5:Circuit diagram of power supply

3.5 ESP8266

The ESP8266 is a low-cost, low-power micro controller developed by Espressif Systems, primarily designed for adding Wi-Fi connectivity to embedded systems and IoT (Internet of Things) projects. While not as powerful as its successor, the ESP32, the ESP8266 remains a popular choice for many developers due to its simplicity, ease of use, and affordability. It's widely used in various applications like home automation, sensor networks, and wireless communication projects.

Fig 3.6:ESP8266 controller

Tensilica L106 processor running at up to 80 MHz (over clockable to 160 MHz), with 160 KB of SRAM and external flash storage ranging from 512 KB to 16 MB. The micro controller supports WiFi standards 802.11 b/g/n, offering speeds up to 72.2 Mbps and a variety of security protocols, including WPA2 encryption. With 17 GPIO pins, the ESP8266 supports multiple peripherals such as PWM, ADC, SPI, and I2C, making it suitable for a range of applications like home automation, wireless sensor networks, and IoT devices. It is compatible with development environments like the Arduino IDE and NodeMCU, simplifying the development process. Despite its relatively low processing power compared to newer micro controllers like the ESP32, the ESP8266 remains popular for simple, Wi-Fibased projects due to its affordability, compact size, and ease of use.

The ESP8266 is a popular micro controller developed by Espressif Systems, widely recognized for its affordability and versatility in wireless communication applications. With its built-in Wi-Fi support, it allows developers to easily integrate wireless connectivity into projects without the need for additional modules. Powered by a single-core Tensilica L106 processor, the ESP8266 offers up to 160 MHz clock speed (when overclocked), providing sufficient power for most IoT and automation tasks. It features 160 KB of RAM and external flash memory options ranging from 512 KB to 16 MB, which is ideal for storing code and managing data.

Despite its relatively simple design compared to newer chips like the ESP32, the ESP8266 is still a great option for basic applications requiring Wi-Fi connectivity. It supports 802.11 b/g/n Wi-Fi standards and offers various encryption methods such as WPA/WPA2, ensuring secure wireless communication. The 17 GPIO pins provide ample flexibility for interfacing with sensors, actuators, and other peripherals, including PWM, ADC, SPI, and I2C. While it only has a 10-bit ADC, it's sufficient for basic analog signal processing tasks like reading sensor values.

3.5.1 Applications of ESP8266

The rising challenge of vehicle theft impacts various stakeholders, including vehicle owners, insurers, security companies, and the community. To tackle this issue, tracking devices provide a viable and budget-friendly solution. Tracking mechanisms arise as a practical response to this problem, offering a reliable and cost-effective means to address the intricate issue of vehicle theft. This paper introduces an innovative tracking system that seamlessly integrates GSM communication, GPS technology, and web-based visualization to enable real-time monitoring of vehicles or objects. The system's operational sequence commences with a registration process, accomplished by sending an SMS code to the GSM module, ensuring secure access and authorized interaction. Successful registration prompts a confirmation message, solidifying the system's foundation of trust.The system uses GPS technology to retrieve real-time longitude and latitude coordinates, providing users with accurate location data.

1. **Home Automation:**
   - Integration with platforms like Google Home, Amazon Alexa, and custom mobile apps.
2. **Wireless Sensor Networks:**
   - Collect data from various sensors (temperature, humidity, motion) and send it over Wi-Fi to a central server or cloud service

3.5.2 Popular ESP8266 Modules

1. **ESP-01**:One of the most basic and common variants, offering limited GPIOs and functionality.
2. **NodeMCU**: A development board with integrated USB-to-serial adapter, making it easier.
3. **We mos D1 Mini:** A smaller form-factor development board, compatible with the Arduino IDE and equipped with a USB port for easy programming.
4. **ESP-12E**: A more powerful version with more GPIO pins and greater memory capacity compared to the ESP-01, often used for more complex applications.

Advantages and Limitations

Advantages:

1. **Low Cost**: One of the most affordable micr ocontrollers with Wi-Fi capability.
2. **Compact Size**: Suitable for projects with limited space.
3. **Ease of Use**: Extensive support from the Arduino IDE and other development platforms makes it accessible to both beginners and advanced users.
4. **Low Power Consumption**: Ideal for battery-powered projects with the ability to enter deep sleep modes

Limitations:

- **Limited Processing Power**: While suitable for basic IoT tasks, the ESP8266's single-core processor and lower clock speeds might not be enough for more demanding applications compared to the ESP32.
- **Limited GPIO Pins**: The ESP8266 has fewer GPIO pins than other micro controllers like

the ESP32, which could limit more complex hardware interfacing

- **No Bluetooth**: Unlike the ESP32, the ESP8266 does not support Bluetooth connectivity. The chip was popularized in the English-speaking maker community in August 2014 via the ESP01 module, made by a third-party manufacturer Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayesstyle commands. However, at first, there was almost no English-language documentation on the chip and the commands it accepted. The very low priceand the fact that there were very few external components on the module, which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, the chip, and the software on it, as well as to translate the Chinese documentation. The ESP8285 is a similar chip with a built-in 1 MiB flash mem.

Features

- Processor: L106 32-bit RISC micronprocessor core based on the Tensilica diamond Standard

  106Micro running at 80 or 160 MHz[5]
- Memory:[6]
- 32 KiB instruction RAM
- 32 KiB instruction cache RAM
- 80 KiB user-data RAM
- 16 KiB ETS system-data RAM
- External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included)
- IEEE 802.11 b/g/n Wi-Fi
- Integrated TR switch, balun, LNA, power amplifier and matching network
- WEP or WPA/WPA2 authentication, or open networks
- 17 GPIO pins[7]
- Serial Peripheral Interface Bus (SPI)
- I²C (software implementation)[8]

- I²S interfaces with DMA (sharing pins with GPIO)
- UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
- 10-bit ADC (successive approximation ADC.

Ai-Thinker modules

This is the first series of modules made with the ESP8266 by the third-party manufacturer Ai Thinker and remains the most widely available.[20] They are collectively referred to as "ESP-xx modules". To form a workable development system, they require additional components, especially a serial TIL-toUSB adapter (sometimes called a USB-toUART bridge) and an external 3.3 volt power supply. Novice ESP8266 developers are encouraged to consider larger ESP8266 Wi-Fi development boards like the NodeMCU which includes the USB-to-UART bridge and a Micro-USB connector coupled with a 3.3 volt power regulator already built into the board. When project development is complete, those components are not needed and these cheaper ESP-xx modules are a lower power, smaller footprint option for production runs.

In 2020, Espressif announced a new chip, ESP32-C3, which is pin-compatible with ESP8266. It is based on a single core RISC-V 32-bit CPU with a clock speed of up to 160 MHz. It includes 400 KiB of SRAM and 384 KiB ROM storage space built.

The ESP8266, despite being an older chip compared to its more powerful successor, the ESP32, still excels in many applications due to its compact size, affordability, and efficient Wi-Fi integration. Its core is designed for low-energy, connected devices, with features like deep sleep mode allowing for ultra-low power consumption, making it an excellent choice for battery-powered devices like remote sensors or wearable technology. The 17 GPIO pins provide substantial flexibility in handling digital input/output, PWM control, and analog-to-digital conversion (ADC), although with some limitations, like a single ADC channel and a 10-bit resolution. This is adequate for many basic IoT devices such as weather stations, smart plugs, or environmental sensors.

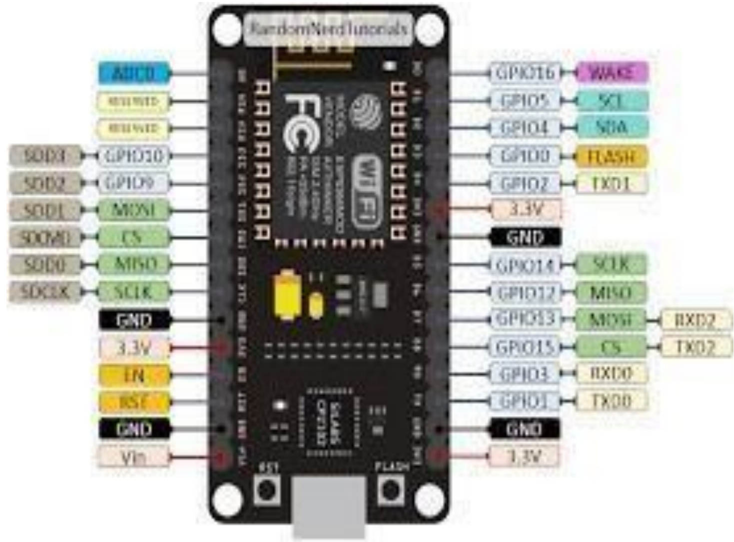


Fig.3.7:Esp8266.Internal Structure

Its external flash memory can range from 512 KB to 16 MB, offering sufficient space for applications to store their firmware and data, with the added ability to use SPI Flash for quicker read/write speeds. The Wi-Fi connectivity provided supports speeds of up to 72.2 Mbps, enough for most IoT communication tasks such as transmitting sensor data, controlling devices over the internet, or connecting to cloud services. However, the ESP8266's biggest limitation in comparison to the ESP32 is the absence of Bluetooth support, which restricts its use for projects requiring Bluetooth communication.

The ESP8266 is compatible with widely used development platforms such as Arduino IDE, NodeMCU, and Micro python, allowing developers from beginner to expert level to work with it easily. It is also supported by numerous libraries and frameworks that simplify tasks like MQTT, HTTP, and cloud integration, enabling developers to rapidly prototype and deploy connected solutions. Its low cost, availability in development boards like NodeMCU and Wemos D1 Mini, and vast online community support make the ESP8266 a go-to solution for low-power, wireless communication projects in the IoT ecosystem.

In conclusion, the ESP8266 is a reliable and cost-effective microcontroller, offering a powerful combination of Wi-Fi connectivity, low power consumption, and ease of development, making it ideal for a variety of IoT applications, ranging from simple smart home devices to more advanced sensor networks. While it lacks some of the more advanced features of newer chips like the ESP32, such as higher processing power or Bluetooth capabilities, it continues to serve as a robust option for simpler, Wi-Fi-centric IoT projects.

The ESP8266 continues to be one of the most popular microcontrollers in the IoT space due to its combination of affordability, compactness, and powerful Wi-Fi capabilities. Despite being superseded by the more feature-rich ESP32, the ESP8266 remains a highly effective choice for many applications. It integrates easily into projects that require Wi-Fi connectivity but do not need the added complexity or power of the ESP32. The single-core Tensilica L106 processor running at 80 MHz (up to 160 MHz when overclocked) handles simple tasks such as connecting to networks, processing sensor data, or controlling devices, all while consuming very little power. Its 160 KB of SRAM and the ability to handle up to 16 MB of flash memory provide ample space for firmware and basic data storage, making it a great choice for prototyping and small-scale production devices.

One of the standout features of the ESP8266 is its built-in Wi-Fi support (802.11 b/g/n), which enables easy internet connectivity and communication over the wireless network. The Wi-Fi module allows devices to connect to routers, APs, or operate as an access point, and it supports data rates up to 72.2 Mbps, which is sufficient for a wide range of IoT applications like remote monitoring, control systems, and cloud-based services. The chip also supports security protocols such as WPA2, WEP, and WPA, ensuring that communication is encrypted and safe.

For peripheral interfacing, the ESP8266 provides 17 GPIO pins, which are capable of supporting PWM, I2C, SPI, UART, analog input (ADC), and digital input/output. These pins can be configured to perform a variety of tasks such as reading sensor data, controlling LEDs, or communicating with other microcontrollers. The 10-bit ADC in the ESP8266 is especially useful for applications where analog signal processing is required, such as reading from temperature sensors, light sensors, or analog devices.

The car seat alert system is designed to integrate seamlessly into daily life, utilizing technology to prevent tragedies caused by vehicular heatstroke. The system's core components are chosen for their reliability and efficiency. The NodeMCU microcontroller acts as the central hub, coordinating inputs from various sensors and triggering appropriate alerts. The temperature sensor module continuously monitors the temperature inside the vehicle, focusing on the area around the car seat. If the temperature exceeds a predefined threshold, the system sends a real-time notification to parents or guardians via the Telegram application. This ensures immediate awareness and swift action to prevent harm to the child.

In addition to temperature monitoring, the system features an advanced child detection mechanism. Pressure sensors embedded in the car seat detect the presence of a child. If the car is locked with a child still seated, the system triggers a series of escalating alerts, including an audible alarm, a visual notification on the LCD screen, and a direct message to the parent's smartphone. These layers of alerts ensure redundancy, enhancing the system's reliability.

The choice of the Telegram application as the primary communication platform is based on its widespread use and ability to send real-time notifications efficiently. By leveraging Telegram's features, the system can provide alerts regardless of distance, allowing parents to be informed even if they are not in close proximity to the vehicle. Furthermore, Telegram's compatibility with automation and integration tools simplifies the system's implementation, making it both user-friendly and scalable.

Extensive testing and research were conducted during the development phase to ensure the system's effectiveness and accuracy. Various scenarios, including different environmental conditions and user behaviors, were simulated to validate the system's performance. The findings indicate that the car seat alert system significantly reduces the risk of vehicular heatstroke by providing timely and actionable alerts to parents.

The project's societal impact cannot be overstated. Vehicular heatstroke is a preventable tragedy, and this system addresses the issue by combining technology and practicality. By raising awareness and equipping parents with an effective tool, the car seat alert system has the potential to save lives and bring peace of mind to countless families. Future developments could include the integration of additional safety features, such as GPS tracking, vehicle ventilation control, and integration with smart home systems, further enhancing.

Another key feature of the ESP8266 is its low power consumption. The chip is capable of entering several low-power states, including deep sleep mode, where the current consumption can drop to as low as 10 µA, making it highly suitable for battery-operated devices and remote sensors. This energy efficiency is crucial for long-term deployments, where devices may be required to operate for months or even years without frequent battery changes.

The ESP8266 is also supported by a rich ecosystem of development tools and frameworks, which make it easier for developers to get started. Its integration with Arduino IDE allows developers to write code in C/C++, taking advantage of a vast library of existing code and community-driven projects. The NodeMCU firmware is another popular option, offering Lua scripting for those who prefer a more script-driven approach. Additionally, Micro python and PlatformIO provide other programming environments that cater to different user preferences and skill levels. These flexible development options, combined with a wealth of online resources and tutorials, make the ESP8266 an ideal choice for both beginners and experienced developers.

Fig.3.8:ESP8266 Board

Moreover, the Node MCU and Wemos D1 Mini development boards, equipped with the ESP8266, provide easy-to-use USB connections, making them ideal for prototyping. These development boards often come with pre installed firmware, allowing for immediate programming via a simple USB to serial connection. The simplicity of setting up the ESP8266 in these development boards, coupled with extensive documentation and community support, allows developers to quickly move from concept to deployment The ESP8266 is a low-cost, WiFi enabled micro controller module widely used in Internet of Things (IoT) projects and applications. It integrates a complete Wi-Fi solution, including a TCP/IP stack, allowing it to connect to wireless networks and communicate with other devices over the internet. This makes the ESP8266 ideal for projects that require remote control, data collection, or wireless communication, such as smart home automation, weather stations, and IoT sensors.

One of the key features of the ESP8266 is its ability to function as both a client and a server, making it versatile for different types of IoT applications. It supports various communication protocols, including HTTP, MQTT, and Web Sockets, enabling it to send and receive data to and from remote servers or cloud platforms. Additionally, the ESP8266 is compatible with popular development platforms like Arduino IDE and Node MCU, making it accessible for both beginners and advanced users

A temperature sensor module is a vital component in child safety systems, particularly in preventing vehicular heatstroke. This module continuously monitors the temperature inside a vehicle, especially around the car seat, to ensure the environment remains safe for the child. When the temperature exceeds a predefined threshold, typically between 37°C to 40°C, the sensor sends signals to a micro controller, such as Node MCU, to trigger alerts. These alerts may include audible alarms, messages to the parent's smartphone via applications like Telegram, or visual warnings on an LCD display. The rapid heating of a vehicle's interior—where temperatures can rise by over 19°C within just 10 minutes on a sunny day—makes this feature indispensable. Children are particularly vulnerable, as their bodies heat up 3-5 times faster than adults. By providing precise, real-time monitoring and automated warnings, temperature sensor modules ensure a reliable, cost-effective, and scalable solution to safeguard children and prevent vehicular heatstroke incidents.

The ESP8266 is a low-cost, Wi-Fi-enabled microcontroller developed by Espressif Systems, widely used in IoT applications. It features a 32-bit Tensilica L106 processor running at 80 MHz, with support for Wi-Fi (802.11 b/g/n), TCP/IP, and various communication protocols like UART, SPI, and I2C. Operating at 3.3V, it has multiple GPIO pins for interfacing with sensors and actuators, making it ideal for smart home automation, remote monitoring, and IoT-based applications. With its low power consumption, built-in flash memory, and deep sleep mode, the ESP8266 is a popular choice for developers and hobbyists. It can be programmed using Arduino IDE, MicroPython, or AT commands for easy integration into projects.

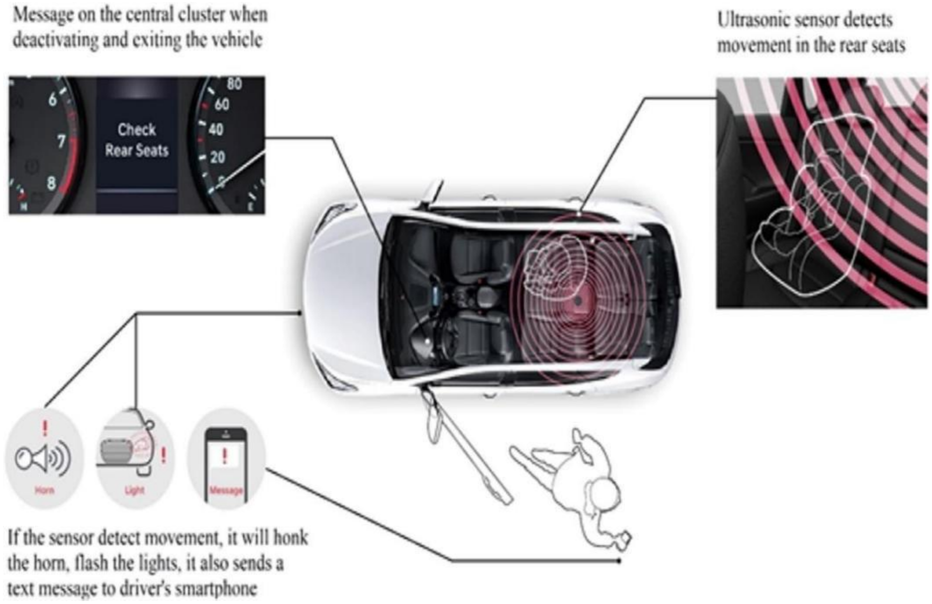


Fig.3.9:Illusion of project

BUZZER

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or key stroke. Buzzer is an integrated structure of electronic transducers, DC power supply, widely used in computers, printers, copiers, alarms, electronic toys, automotive electronic equipment, telephones, timers and other electronic products for sound devices. Active buzzer 5V Rated power can be directly connected to a continuous sound, this section dedicated sensor expansion module and the board in combination, can complete a simple circuit design, to "plug and play.

A buzzer is a compact audio signaling device widely used in electronic applications. It emits sound in response to an electrical signal and is commonly found in alarm systems, timers, household appliances, and automotive warning systems. Buzzers can produce a range of sounds, from simple beeps to continuous tones, depending on the circuit design and input signal.

PRODUCT DESCRIPTION

Fig 3.10:Buzzer

FEATURES:

Input supply: 5 VDC

- Current consumption: 9.0 mA max.
- Oscillating frequency: 3.0 ±0.5 KHz
- Sound Pressure Level: 85dB min.

A buzzer is an electronic sound-producing device commonly used in alarms, timers, and notification systems. It generates sound through electrical signals, which cause internal components to vibrate, producing an audible tone. Buzzers come in two main types: piezoelectric buzzers, which use piezoelectric materials to create sound, and electromechanical buzzers, which rely on a vibrating diaphragm and coil mechanism. They operate on low voltage, making them ideal for integration into circuits for applications such as security systems, household appliances, and industrial equipmentS.

CHAPTER-4
SOFTWARE REQUIREMENTS

4.1 ARDUINO SOFTWARE

The Arduino is a family of microcontroller boards to simplify electronic design, prototyping and experimenting for artists, hackers, hobbyists, but also many professionals. People use it as brains for their robots, to build new digital music instruments, or to build a system that lets your house plants tweet you when they're dry. Arduinos (we use the standard Arduino Uno) are built around an ATmega microcontroller — essentially a complete computer with CPU, RAM, Flash memory, and input/output.

What you will need:

- A computer (Windows, Mac, or Linux)
- An Arduino-compatible microcontroller (anything from this guide should work)
- A USB A-to-B cable, or another appropriate way to connect your Arduinocompatible microcontroller to your computer (check out this USB buying guide if you're not sure which cable to get).

Fig 4.1:Arduino UNO

- An Arduino Uno
- Windows 7, Vista, and XP
- Installing the Drivers for the Arduino Uno (from Arduino.cc)
- Plug in your board and wait for Windows to begin it's driver installation process After a few moments, the process will fail, despite its best efforts
- Click on the Start Menu, and open up the Control Panel
- Look under Ports (COM & LPT). You should see an open port named "Arduino

UNO (COMxx)".

- While in the Control Panel, navigate to System and Security. Next, click on System Once the System window is up, open the Device Manager.

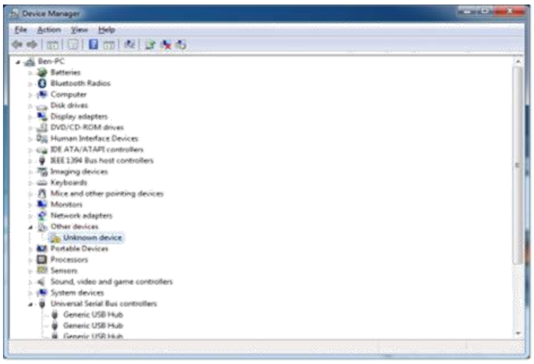


Fig 4.2:Device Manager

- If there is no COM & LPT section, look under 'Other Devices' for 'Unknown Device'.
- Right click on the "Arduino UNO (COMxx)" or "Unknown Device" port and choose the "Update Driver Software" opti Next, choose the "Browse my computer for Driver software" option.

Fig 4.3:Update Driver Software

- Finally, navigate to and select the Uno’s driver file, named “ArduinoUNO.inf”, located in the “Drivers” folder of the Arduino Software download (not the “FTDI USB Drivers” sub-directory).
- If you cannot see the .inf file, it is probably just hidden. You can select the ‘drivers’ folder with the ‘search sub-folders’ option selected instead.
- Windows will finish up the driver installation.
- After following the appropriate steps for your software install, we are now ready to test your first program with your Arduino board!
- Launch the Arduino application
- If you disconnected your board, plug it back in
- Open the Blink example sketch by going to: File > Examples > 1.Basics > Blink
- After a second, you should see some LEDs flashing on your Arduino, followed by the message ‘Done Uploading’ in the status bar of the Blink sketch.

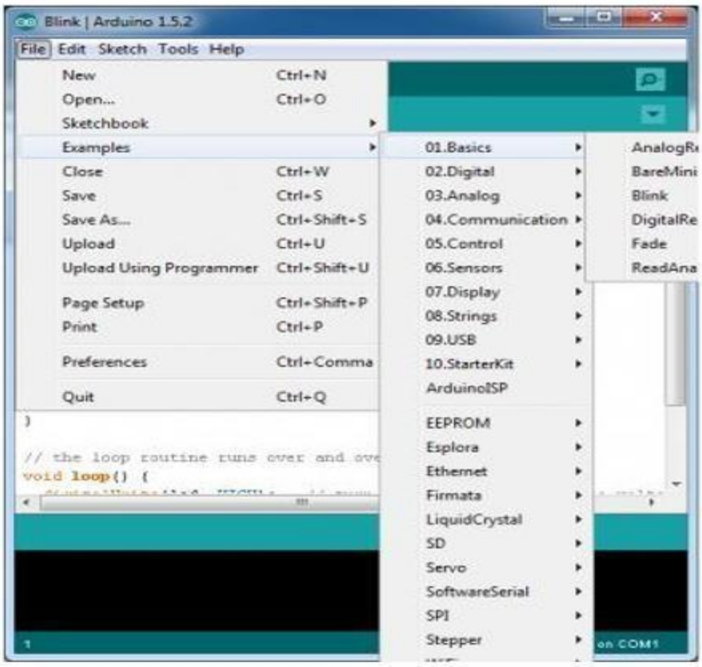


Fig 4.4:Arduino File basics

- If everything worked, the onboard LED on your Arduino should now be blinking! You just programmed your first Arduino!
- Select the type of Arduino board you’re using: Tools > Board > your board type

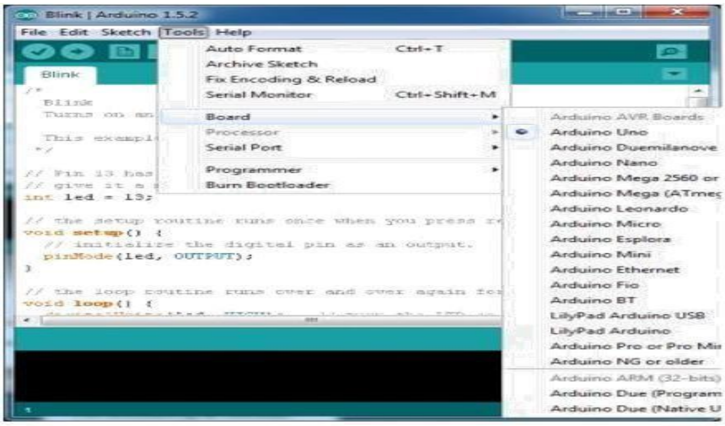
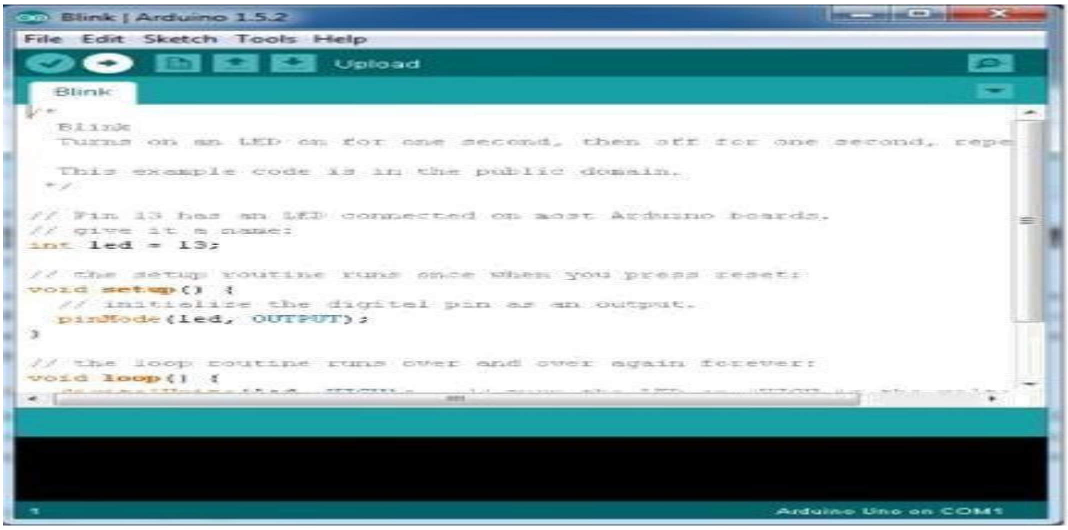


Fig 4.5:Arduino Tools Board

- Select the serial/COM port that your Arduino is attached to: Tools > Port > COMxx

- If you’re not sure which serial device is your Arduino, take a look at the available ports, then unplug your Arduino and look again.
- The one that disappeared is your Arduino.With your Arduino board connected, and the Blink sketch open, press the ‘Upload’ button.



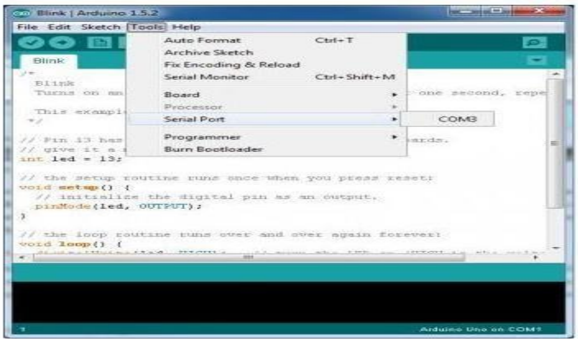


Fig 4.6:Blink Arduino Tools

4.2 ARDUINO DRIVERS

1. What Are Arduino Drivers?

Arduino drivers are software components that allow your computer to communicate with the Arduino board through a USB connection. Without the proper drivers, your computer will not recognize the Arduino board, preventing you from uploading programs or monitoring data.

2. **Why Are Arduino Drivers Needed?**

- Enable data transfer between the Arduino IDE and the Arduino board.
- Allow the computer to detect the Arduino board via the USB port.

- Essential for using Serial Monitor and Serial Plotter in the Arduino IDE.
- Required for programming Arduino-compatible boards like ESP32 and ESP8266.

3. **How to Install Arduino Drivers?**

1. **Automatic Installation (Windows)**
   - Download and Install the Arduino IDE from Arduino Official Site.
   - During installation, check the box to install drivers.
   - After installation, connect the Arduino board via USB.
   - Windows will automatically detect and install the required drivers.

2. **Manual Installation (Windows)**
   - Go to Device Manager (`Win + X → Device Manager`).
   - Look for an unrecognized device under Ports (COM & LPT) or Other Devices
   - Right-click and select Update Driver Software.
   - Choose Browse my computer for drivers and navigate to:C:\Program Files (x86)\Arduino\drivers
   - Click Next to install the driver.

3. **Installation on macOS**
   - Install the Arduino IDE from the official site.
   - Plug in your Arduino board; macOS usually detects it automatically.
   - If the board is not detected, install the appropriate CH340, CP210x, or FTDI driver from their respective sources.

4. Installation on Linux
   - Open the terminal and run

4.3 LIBRARIES

1.What Are Arduino Libraries?

Arduino libraries are collections of pre-written code that simplify programming for specific components like sensors, displays, motors, and communication modules. Instead of writing complex code from scratch, libraries provide ready-to-use functions to control hardware efficiently.

2.Why Use Arduino Libraries?

- **Saves Time** – Avoid writing long, complex code for hardware components.

- **Simplifies Programming** – Provides easy-to-use functions.
- **Supports Multiple Components** – Libraries exist for sensors, motors, communication modules, etc.
- **Official & Community Support** – Thousands of free libraries are available.

3.How to Install Arduino Libraries?

1. Using Arduino Library Manager (Recommended)

- Open Arduino IDE.
- Go to Sketch → Include Library → Manage Libraries.
- In the Library Manager, search for the library name.
- Click Install and wait for the installation to complete

2. **Installing Libraries Manually (.ZIP File)**

- Download the `.zip` file from GitHub or Arduino's website.
- Open Arduino IDE → Go to Sketch → Include Library → Add .ZIP Library.
- Select the downloaded .zip file and click Open.

3. **Installing Libraries Manually (Folder Method)**

   - Download the library folder.
   - Extract it and move the folder to:Windows**:** Documents\Arduino\libraries\
   - Restart **Arduino IDE**.

CHAPTER -5

WORKING MODEL AND ITS COMPONENTS

5.1 BLOCK DIAGRAM

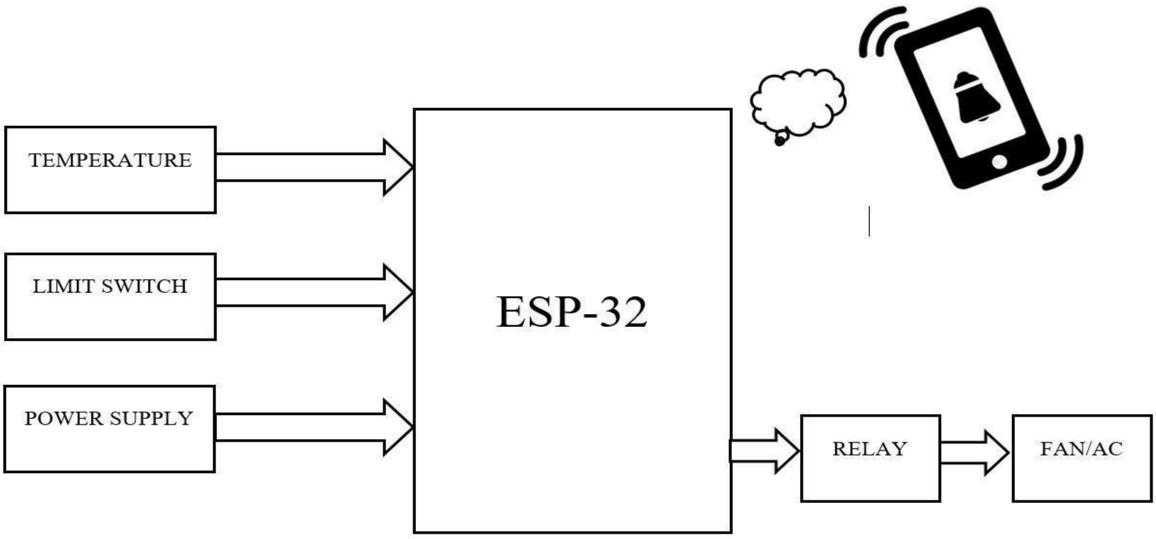


Fig 5.1:Block Diagram of working model

5.2 WORKING

5.2.1 Introduction to ESP32 Micro Controller:

ESP32 is a powerful, low-cost, and power-efficient microcontroller series developed by Espressif Systems. It is widely used in IoT, embedded systems, and smart device applications due to its advanced features like built-in Wi-Fi, Bluetooth, and multiple peripherals.

The ESP32 is a highly integrated and power-efficient microcontroller developed by Espressif Systems, widely used in IoT and embedded systems. It features a dual-core Xtensa LX6 processor with a clock speed of up to 240 MHz, built-in Wi-Fi (802.11 b/g/n), and Bluetooth 4.2/BLE, making it ideal for wireless applications. With up to 34 GPIOs, 12-bit ADC, 8-bit DAC, and support for I2C, SPI, UART, and PWM, it offers extensive connectivity options. The ESP32 also includes capacitive touch sensors, an RTC (Real-Time Clock) for low-power applications, and hardware AES encryption for security. Supporting multiple power-saving modes such as deep sleep and hibernation, It is well-suited for battery-powered devices. It can be programmed using Arduino IDE, ESP-IDF, MicroPython, or PlatformIO, making it accessible to both beginners and professionals. Available in various versions like ESP32-WROOM-32, ESP32-WROVER, and ESP32-S3, it is widely used in

IoT, home automation, robotics, smart agriculture, and industrial automation.

The ESP32 microcontroller is a powerful and feature-rich development board that has gained popularity in the fields of IoT, smart devices, and embedded systems due to its high performance and energy efficiency. Manufactured by Espressif Systems, it comes with a dual-core Xtensa LX6 processor, running at speeds up to 240 MHz, and is equipped with 520 KB SRAM and 4 MB Flash memory for efficient processing and storage. One of its standout features is built-in Wi-Fi and Bluetooth 4.2/BLE, which enables seamless wireless communication for smart applications. It supports multiple peripherals such as I2C, SPI, UART, PWM, ADC (12-bit), DAC (8-bit), and touch sensors, making it highly adaptable to various projects. Additionally, the ESP32 is known for its low-power modes, including light sleep, deep sleep, and hibernation, making it ideal for battery-operated devices. It supports multiple development environments, including Arduino IDE, ESP-IDF, MicroPython, and PlatformIO, catering to both beginners and advanced users. Due to its high processing power, built-in security features like AES encryption and secure boot, and support for external SD cards, the ESP32 is widely used in home automation, wearable devices, robotics, industrial automation, and AI-based applications. Its low cost, versatility, and strong community support make it a preferred choice for developers worldwide.

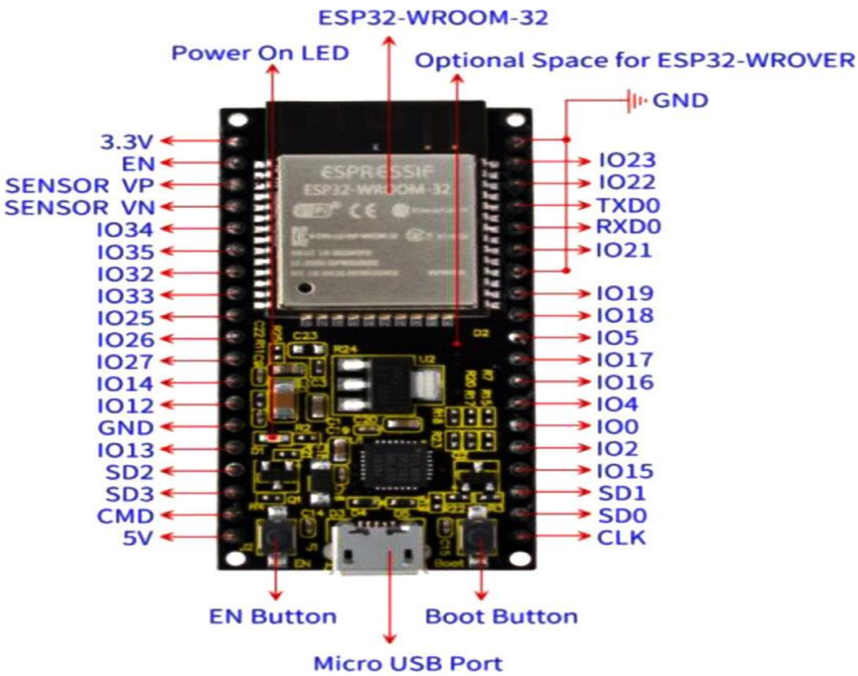


Fig 5.2:Structure of ESp32 microcontroller

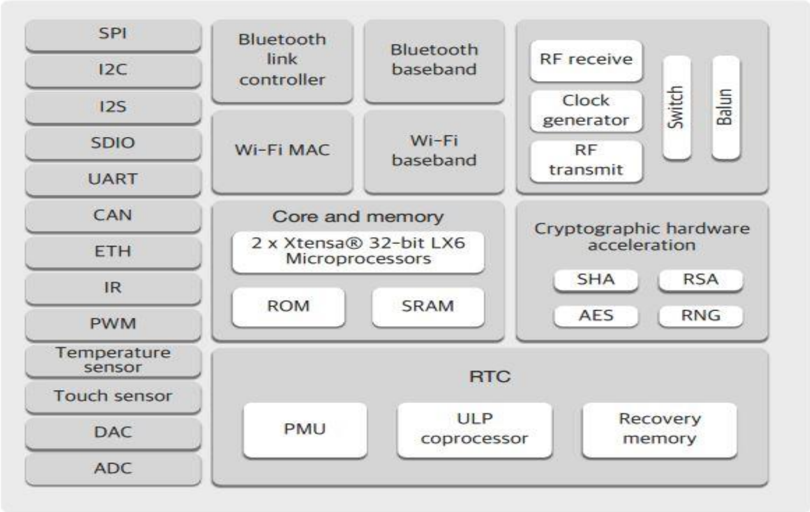


Fig5.3:Esp32 architecture

The ESP32 microcontroller is a highly integrated and versatile chip that features a dual-core Xtensa® 32-bit LX6 processor with built-in Wi-Fi and Bluetooth capabilities, making it ideal for IoT and embedded applications. It includes a range of peripherals such as SPI, I2C, I2S, UART, CAN, and Ethernet, enabling seamless communication with external devices. The chip also supports PWM for motor and LED control, ADC and DAC for analog signal processing, and capacitive touch sensors for interactive applications. Additionally, it comes equipped with an internal temperature sensor and a Real-Time Clock (RTC) module with a ULP (Ultra-Low Power) coprocessor, allowing efficient power management. For security, the ESP32 integrates cryptographic hardware acceleration, supporting SHA, AES, RSA, and RNG, ensuring data encryption and secure transactions. The RF module manages Wi-Fi MAC, Wi-Fi baseband, Bluetooth link control, and RF transmission/reception, allowing robust wireless connectivity. With its extensive features, low power consumption, high processing speed, and multiple interfacing options, the ESP32 is widely used in IoT applications, smart home automation, industrial control systems, and AI-powered devices, making it one of the most popular microcontrollers in modern embedded systems.

The system is designed to monitor and control the internal environment of a vehicle using a central processing unit (CPU), which acts as the brain of the operation. It collects real-time data from temperature sensors to measure the internal heat levels and limit switches to detect door or window positions. The CPU continuously analyzes these conditions and determines whether the environment inside the vehicle is safe. If it detects an unsafe situation, such as excessively high temperatures or inadequate ventilation, it immediately sends an alert to the user's smartphone via Wi-Fi, Bluetooth, or GSM-based notifications. Additionally, the system can take automated actions to regulate the temperature by controlling a relay module, which turns on cooling devices like a fan or air conditioning (AC) unit. This ensures a safer and more comfortable vehicle interior, preventing overheating risks for passengers, pets, or sensitive electronics. The integration of sensor-based monitoring, wireless alerts, and automated cooling mechanisms makes this system highly efficient for smart vehicle management and IoT-based safety applications.

5.2.2 Temperature Sensor

A temperature sensor is an electronic device that detects and measures temperature variations in an environment and converts them into an electrical signal. These sensors are widely used in automotive systems, industrial automation, IoT applications, medical devices, and home automation for monitoring and controlling temperature levels.

The temperature sensor helps monitor the interior environment of the car, specifically the temperature inside the vehicle. This is particularly critical for preventing heatstroke in children, which can be a serious risk when a child is left in a car, even for a short period of time.

- **DHT11 or DHT22 Temperature and Humidity Sensor:**

1. **DHT11**: It's a basic, low-cost digital sensor for measuring temperature and humidity. It provides a temperature range of 0°C to 50°C with an accuracy of ±2°C.

2. **DHT22**: It is more accurate and provides a wider range of temperature and humidity measurements. It works between -40°C to 80°C and has an accuracy of ±0.5°C, making it more suitable for applications where precision is crucial.

- **How it Works?**

1. **Data Collection:**The DHT11/DHT22 sensor continuously monitors the temperature and humidity inside the car.The sensor sends temperature data to the ESP-32 using a digital signal over a single-wire connection. The DHT sensor communicates with the ESP-32

using a predefined protocol, which the ESP-32 can decode to retrieve the temperature data.

2. **Threshold Comparison:**The ESP-32 is programmed with a predefined safe temperature threshold (e.g., 30°C or 86°F).The ESP-32 constantly compares the current temperature, read from the DHT sensor, against the threshold.

3. **Action Triggering:**If the temperature exceeds the safe limit, the ESP-32 triggers a predefined action. This action could include:

- **Activating an Alarm/Buzzer:** A loud alert to notify the driver or anyone near the vehicle that the temperature has become unsafe.
- **Sending SMS Alerts:** The ESP-32 can communicate with a GSM module (e.g., **SIM800L**) to send an SMS alert to the parent or caregiver, including the current temperature reading.
- **Mobile App Notification:** If the system is connected to a smartphone app via Wi-Fi or Bluetooth, the ESP-32 can send real-time notifications through the app, alerting the user to the dangerous condition.
- **Power Management:**The ESP-32 is energy-efficient, but since the system will run continuously, the vehicle's power source (12V car battery) can be used to power the system. Low-power modes of the ESP-32 can be used when the system is idle to save battery power, and it will be activated again when it detects a temperature change.

5.2.3 Limit Switch

A Limit Switch is a crucial component in a child safety alert system as it helps detect whether the car doors are fully closed and ensures the system is only activated when the vehicle is locked. This prevents false alerts and ensures the system operates efficiently.

1. **Purpose of the Limit Switch in the System:**The **limit switch** helps determine:

   - Whether the **car doors are fully closed** before activating the temperature monitoring system.
   - If the **vehicle is locked**, which helps avoid unnecessary alerts when doors are open.
   - Whether a **child is left inside a locked car**, ensuring that temperature alerts.

2. **How the Limit Switch Works:**

   1. **Placement in the Vehicle:**The limit switch is installed near the door latch or frame to detect when the door is completely closed.It can be placed on each door or just on the rear doors where a child safety system is needed.

2. **Working Mechanism:**A normally open (NO) limit switch remains open when the door is open and closes the circuit when the door is shut.A normally closed (NC) switch works oppositely, breaking the circuit when the door is shut.When the doors are fully closed, the switch sends a signal to the ESP-32 microcontroller, allowing the system to activate.
3. **Interfacing with the ESP-32:**
   - The limit switch is connected to a **digital input pin** of the ESP-32.
   - When the door is closed, the switch status changes, and the ESP-32 reads the signal.
   - If all monitored doors are closed and locked, the system starts monitoring temperature levels.
4. **Integration with Other Sensors:**
   - The limit switch works alongside a temperature sensor (DHT11/DHT22) and a motion or pressure sensor (to check if someone is inside the car).
   - It ensures that alerts are only triggered if a child is left inside a locked vehicle with a high internal temperature.

5.2.4 Power Supply

The power supply is a crucial component of the Child Safety Alert System, ensuring all electronic modules function reliably and efficiently. The system primarily operates using a regulated power source to support components like the ESP-32/NodeMCU, sensors, relay module, and GSM/GPS modules.

Voltage Regulation & Distribution:

Since different modules in the system require different voltage levels, proper voltage regulation is essential.

- ESP-32/NodeMCU: Requires 3.3V (regulated using AMS1117-3.3V voltage regulator).
- Sensors (DHT11/DHT22, Limit Switch): Operate on 3.3V or 5V, depending on the model.
- Relay Module: Operates on 5V or 12V, requiring a separate power supply if multiple relays are used.
- GSM/GPS Module: Typically requires 5V - 12V and a high-current power source (up to 2A) to function properly.

5.2.5 Relay Module

The Relay Module is a key component in the Child Safety Alert System, acting as an electrical switch that allows the ESP-32 microcontroller to control high-power devices such as a fan, air conditioning (AC), or alarm system. The relay operates on a low-voltage signal from the ESP-32 (typically 3.3V or 5V) but can switch higher voltage loads like 12V or 230V AC-powered devices to enhance child safety.

1. **Role of the Relay Module in the Child Safety Alert System:**Activate the Fan or Air Conditioning (AC):If the temperature sensor (DHT11/DHT22) detects a dangerously high temperature inside the car, the ESP-32 triggers the relay to turn on the fan or AC to cool the environment.
2. **Trigger an Alarm or Buzzer:**If the child is detected inside the locked vehicle, the relay can be used to activate a buzzer or car horn to alert nearby people.
3. **Emergency Window Opening (Future Scope):**The relay can be connected to the car's power windows, allowing automatic window opening in case of extreme heat.

1. **How It Works in the System?**

- The temperature sensor (DHT11/DHT22) monitors the internal car temperature.
- If the temperature exceeds the safe limit, the ESP-32 sends a signal to the relay.
- The relay module activates, turning on the fan or AC to cool the environment.
- If the temperature returns to normal, the relay deactivates, switching off the devices

5.2.6 Smartphone Alert System

The Smartphone Alert System is a crucial component of the Child Safety Alert System, designed to notify caregivers when a child is left inside a locked vehicle. This system ensures immediate awareness and enables a quick response to prevent heatstroke or other dangerous situations.

1. How It Works in the System?

Car Door Status Check:

- **The limit switch** detects if the car doors are closed and locked.
- If the car is locked, the system **activates** and starts monitoring.

Temperature Monitoring:

- The DHT11/DHT22 temperature sensor continuously measures the temperature inside the car.

- If the temperature exceeds a predefined safety threshold, the ESP-32 processes the data.

Alert Generation:

- The **ESP-32 sends an alert** to the caregiver's smartphone.
  1. **Wi-Fi (Telegram Notification)** – If the car is in a Wi-Fi-enabled area.
  2. **GSM (SMS/Call Notification)** – If the vehicle is in a remote area without Wi-Fi.

2. **Functionality of the Smartphone Alert System**

- Monitors the car environment using sensors (temperature, limit switch, and motion detection).
- Sends real-time alerts to the caregiver's smartphone via Wi-Fi (using Telegram) or GSM (via SMS/call).
- Ensures remote access to monitor and control the safety system from anywhere.
- Reduces the risk of child fatalities due to overheating in a locked vehicle.

5.2.7 Working Steps of the System

1. Car Lock Detection:

- The **limit switch** is installed on the car door.
- When the car is locked, the switch detects that the doors are closed and **activates the system**.

2. **Temperature Monitoring:**

- The DHT11/DHT22 temperature sensor continuously monitors the internal temperature of the car.
- If the temperature exceeds the critical threshold (e.g., 40°C), the ESP-32 microcontroller processes the data.

3. **Alert Generation to Caregiver:**

- The ESP-32 sends an alert message/notification to the caregiver's smartphone.
- Alerts can be sent via:
  1. **Wi-Fi (Telegram Notification):** If the car is in a Wi-Fi-enabled area.
  2. **GSM (SMS/Call Notification):** If the vehicle is in a remote area

4. **Activation of Cooling System:**

Simultaneously, the relay module is triggered to activate external cooling devices such as:

1. A fan to circulate air inside the car.
2. The car's AC (if integrated with the system) to lower the temperature.

5.3 CLASS DIAGRAM

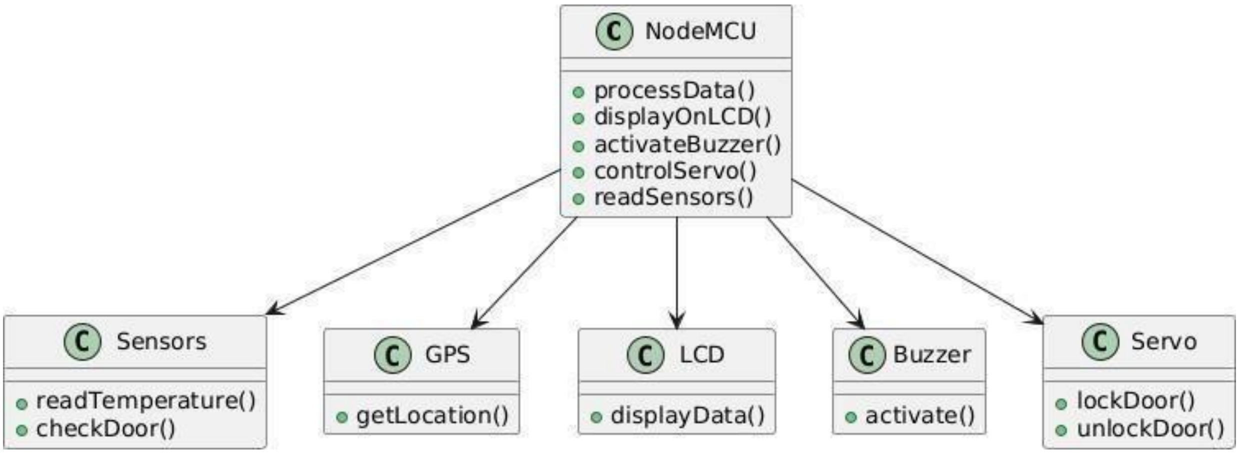


Fig 5.4:Class Diagram

The class diagram represents the static structure of the system, defining its classes, attributes, methods, and the relationships between them. In this system, we have several classes, including Sensor, ArduinoMega, NodeMCU, and Output module. The Sensor class includes attributes such as type and data, with a method measure data for data collection. The Arduino Mega class acts as the main controller, with attributes for storing sensor data and methods to collect, process, and send data. The Node MCU class is responsible for wireless transmission. Output module class displays or stores data locally. Relationships indicate how data flows from the Sensor to Arduino Mega and then to either the Output module or Node MCU, which may transmit data to a cloud server.

5.4 SEQUENCE DIAGRAM

The sequence diagram shows how different components interact over time to complete the data collection and transmission process. The Environment triggers data measurement, which is carried out by the Sensor and sent to the Arduino Mega. The Arduino Mega processes the data and decides whether to send it to the Output module for display or to the Node MCU for transmission. The Node MCU then transmits the data to the Cloud. The Technician can monitor the data either through the Output module or the cloud system. This diagram highlights the chronological order of operations and interactions.

The sequence diagram further emphasizes the seamless interaction between components, ensuring that each part of the system functions harmoniously to achieve the overall goal of efficient data collection, processing, and monitoring. Once the Sensor gathers data, it is transmitted to the Arduino Mega, which serves as the central hub for processing and decision- making. The Arduino Mega not only processes the data but also plays a critical role in determining the next step, whether that be displaying the data locally or sending it to the Node MCU for cloud transmission.

The Output module provides immediate visibility for the Technician, allowing for hands-on intervention if the displayed data indicates an anomaly or requires action. This real-time monitoring helps in situations where immediate corrective measures are necessary, such as adjusting system settings or troubleshooting issues.

On the other hand, the data transmission to the Cloud ensures that the system's data is stored securely and can be accessed remotely. The Node MCU's Wi-Fi capabilities enable seamless communication with the cloud, where the data is not only stored but also analyzed and visualized. Cloud-based analytics can reveal trends, detect abnormalities, and offer insights for future system improvements.

The ability for the Technician to access the system remotely, via the cloud, allows for proactive monitoring and reduces the need for constant on-site presence. This capability is particularly useful in situations where real-time updates are crucial but physical presence is not always possible. By utilizing both local and remote monitoring, the system is equipped to ensure continuous oversight, data integrity, and quick response times in case of any issues, making the entire process more efficient and reliable.

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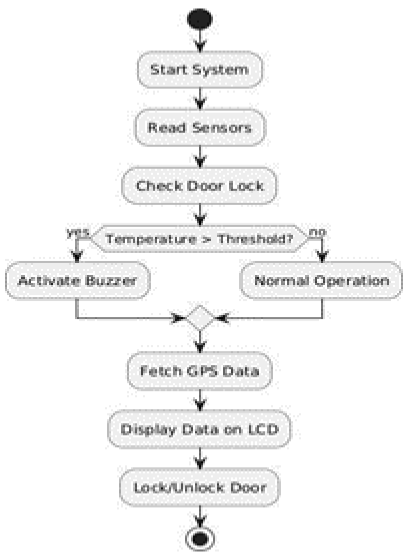

Fig.5.6:Activity Diagram

5.5 OVERVIEW

The Child Safety Alert System is an innovative solution designed to prevent fatal accidents caused by heatstroke in locked vehicles. This system integrates temperature monitoring, real-time alerts, and automated cooling mechanisms to ensure the safety of children left inside a car. The ESP-32 microcontroller serves as the system's core, processing data from a DHT11/DHT22 temperature sensor and a limit switch that detects when the car doors are locked. If the temperature inside the vehicle exceeds a critical threshold, the system automatically sends an alert to the caregiver's smartphone via Wi-Fi (Telegram notification) or GSM (SMS/call), ensuring timely intervention. Simultaneously, the relay module activates a fan or AC to cool down the car's interior, preventing dangerous heat buildup. The system remains active until the temperature returns to a safe level or the caregiver acknowledges the alert. This project provides an efficient, cost-effective, and easy-to-implement solution to enhance child safety in vehicles, reducing the risk of heatstroke-related fatalities. Future advancements may include AI-based child detection, automatic window control, and GPS tracking to further improve safety and accessibility.

CHAPTER – 6

6.1 RESULTS

In the conclusion, the objectives of the detection system are to alert the caregiver about their child to prevent the child from dying because of hyperthermia by sending an alert message through the Telegram Application. The objective of this project was described at the end of this project and it must be achieved by designing a system that can be alert the caregiver which is based on the prototype. With some growth using plywood and Perspex glass, the definition is based on the demand available today. The benefits of the car seat alert system were efficient to remind the child is at the back, most often after getting out from the car hectically.

Then, the caregiver did not have to worry for left their child in the car. Although many parents are about to leave their child inside the vehicle, many of them are dead. This device strengthens safety and protection more than ever. This system is going easy to access by smartphone at Telegram application. Even if the transmission medium scope is a bit limited compared to the GSM system, as well as there is a Wi-Fi link inside the project, it will operate all over the world. The model of the detection method using the Telegram application and Wi- Fi coverage was efficiently archived at a fair price. This development also consists of the NodeMCU Esp8266 and the Neo 6m GPS module, as stated before. It is an efficient GPS module since it monitors up to 22 satellites in all areas of the world. Conclude, the goal of this project was successfully accomplished with the main reason which is to develop the alert system through the Telegram application.

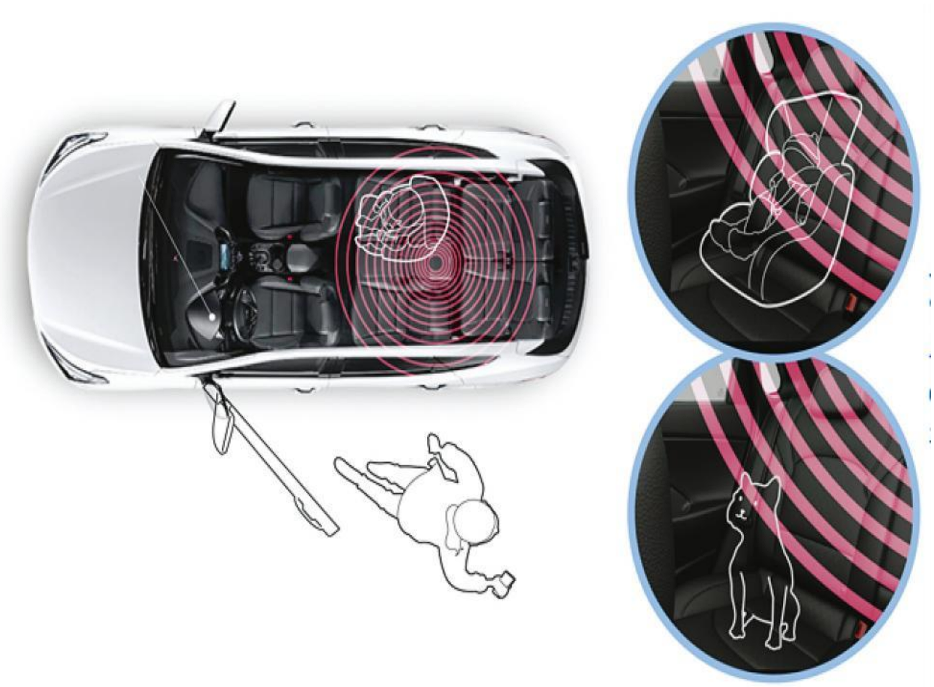

Fig.6.1:Model of the project

6.2 ADVANTAGES

The System offers several key advantages that make it an essential tool for preventing heatstroke-related fatalities in vehicles. By continuously monitoring the internal temperature, the system ensures that children are not left in dangerously hot cars, significantly reducing the risk of heatstroke. Through real-time alerts sent via Telegram or GSM, caregivers are immediately notified if the temperature exceeds a critical threshold, allowing for quick action. The system's automatic cooling mechanisms activate a fan or AC, effectively lowering the temperature inside the car without the need for direct intervention. This cost-effective, easy-to-install solution is globally accessible, functioning through Wi-Fi and GSM, which ensures it works even in areas with limited connectivity. Additionally, the system reduces human error by automating temperature checks and notifications, offering peace of mind to caregivers. It is adaptable to a variety of vehicles, from family cars to school buses, and its scalability makes it a valuable tool for both individual owners and fleet operators. With future enhancements like GPS tracking and AI-based child detection, the system can evolve into an even more comprehensive safety solution, providing continuous protection for children left in vehicles.

6.3 APPLICATIONS

The Child Safety Alert System has a wide range of applications, making it a valuable tool in various scenarios. It can be used in family cars, ensuring that children are not forgotten in a locked vehicle, which is especially useful for busy parents. Additionally, the system is ideal for school buses, where children may be left behind unintentionally, allowing for immediate alerts to bus drivers or school authorities. Taxis and ride-sharing services can also benefit from the system, ensuring that children are safely attended to during transit. Moreover, the system has potential for use in special needs transportation, where caregivers may be more focused on the child's care and forget to check the vehicle's internal conditions. The adaptability of the system makes it suitable for commercial fleets, improving child safety across multiple vehicles. With its ability to function through both Wi-Fi and GSM, the system can operate in various environments, offering global accessibility for caregivers, whether at home or abroad. This makes the system an essential tool in ensuring child safety in vehicles worldwide.

The Child Safety Alert System in cars can be widely applied across personal, commercial, and public transportation sectors. It is especially useful for parents and caregivers to prevent leaving children unattended in vehicles. Schools and daycare centers can use it in buses and vans to ensure no child is left behind. Ride-sharing and taxi services can integrate it to enhance family safety, while car manufacturers can offer it as a built-in feature to meet growing safety standards. Additionally, rental car services and government transport systems can adopt it to improve safety and reduce liability during child transport.

CHAPTER-7

7.1 CONCLUSION

In conclusion, the Child Safety Alert System successfully addresses the critical issue of child safety in vehicles, particularly preventing fatalities due to heatstroke. The system's design, which includes real-time temperature monitoring, automated cooling mechanisms, and immediate alerts sent via Telegram or GSM, ensures that caregivers are quickly notified if a child is left in a dangerous situation. This proactive approach minimizes the risk of heat-related harm, providing peace of mind to parents and caregivers. The system is cost-effective, easy to install, and accessible globally, making it suitable for various vehicles, from family cars to school buses and ride-sharing services. The inclusion of Wi-Fi and GSM communication ensures reliable operation even in remote locations. The project has met its goal of developing an efficient, scalable solution to enhance child safety, and with future enhancements like AI-based child detection and GPS tracking, this system has the potential to evolve into an even more comprehensive safety tool. Overall, this project serves as a valuable contribution to improving child safety in vehicles, offering an essential layer of protection in an increasingly busy.

7.2 FUTURE SCOPE

The future scope of the Child Safety Alert System holds great promise for further enhancing its functionality and impact. One potential development is the integration of AI-based child detection, which would use image recognition or infrared sensors to automatically verify the presence of a child in the car, reducing false alerts and improving accuracy. Additionally, automatic window control could be incorporated, allowing the system to slightly open the windows when the temperature rises beyond a set threshold, providing better ventilation and reducing the risk of heatstroke. Another valuable improvement would be the inclusion of GPS tracking, which would allow caregivers to track the exact location of the vehicle and receive location-based alerts if the child is in danger. The system could also benefit from the addition of voice alerts or notifications to further grab the attention of the caregiver, making sure the alert is not missed. With these advancements, the system could evolve into a more comprehensive and intelligent child safety solution, offering protection.

REFERENCES

[1]. Rudd, R., “Functional Assessment of Unattended Child Reminder Systems”, National Highway Traffic Safety Administration, Washington, DC, 2023

[2].Rao, K. V., Rao, P. K., B Ravi, B., “PIR Sensor Based Robot with HMH Applications”, International Journal of Engineering Research and Development, 12(5), pp. 23-28, 2022

[3] Tejaswini, Koteswar, P., Srinivasulu, M., “A Child-Left-Behind Alerting System Based On Capacitive Sensing Principle”, International Journal of Scientific Engineering and Technology Research, 4(32), 6329-6332, 2021..

[4].Prinima, Pruthi, J., “Evolution of Mobile Communication Network: from 1G to 5G”, International Journal of Innovative Research in Computer and Communication Engineering, 4(4), 224-227,2021..

[5].S.I. Yaniger, “Force Sensing Resistors: A Review Of The Technology”, Electro International,10.1109/ELECTR.1991.718294, 2021

[6]. Hashim N. M. Z., Basri, H. H., Jaafar, A., Aziz, M. Z. A. A., Salleh, A., Ja’afar, A. S., “Child in Car Alarm System Using Various Sensor”. ARPN Journal of Engineering and Applied Sciences, 9(9), 1653-1658, 2020

[7]Evans, M., Hochenbaum, J., Noble, J., Arduino In Action. Shelter Island, NY: Manning., 2020

APPENDIX

Appendix-1: Development of Child Safety Alert System in Car System Overview

- The Child Safety Alert System is designed to prevent the accidental abandonment of children in vehicles.
- The system detects the presence of a child in the car after the engine has been turned off and initiates alerts to ensure timely intervention.

Appendix-2: System Components Required

- **Weight Sensor / Pressure Pad**: Placed in car seats to detect presence.
- **Temperature Sensor**: Monitors internal temperature.
- **Microcontroller**: Node MCU,8266 Micro controller
- **GSM Module / Wi-Fi Module**: For sending alerts.
- **LED Lights**: For in-car alerts.
- **Embedded software:** for sensor integration.
- **Mobile App:** For real-time notifications.

Appendix-3: System Flow Graph

[Start]

↓

[Child Detected in Seat]

↓

[Engine Turned Off + Car Locked]

↓

[Temperature Exceeds Threshold?]

↓ ↓

[Yes] [No]

↓ ↓

[Send Alert] [Continue Monitoring]

↓

[End]

Appendix-4: Mobile Notification Sample (Mockup)
Alert
Message:
🚨
"Child detected in car seat. Car temperature has reached 40°C. Please check immediately!"
These alerts are enabled to the care takers of the child which can alert them to check them immedistely.
With increasing awareness and integration with smart car technologies, this system can become a standard safety feature in all vehicles.

Appendix-5: References for Further Reading

1. NHTSA, "Child Heatstroke Deaths in Vehicles," National Highway Traffic Safety Administration, 2023. [Apr. 8, 2025].

2. R. Bansal and S. Gupta, "IoT Based Child Safety System in Vehicles," Int. J. Eng. Res. Technol. (IJERT), May 2020.

3. Texas Instruments, "Using Temperature Sensors for Automotive Applications," [APR 8,2023].

4. R. Bansal and S. Gupta, "IoT Based Child Safety System in Vehicles," Int. J. Eng. Res. Technol. (IJERT), vol. 9, no. 5, 2020.