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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING (ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING)

EMBEDDED SYSTEM DESIGN

PROJECT REPORT ON

AUTOMATED TRAFFIC SIGNAL CONTROL

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DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING (ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING)

**SCHOOL OF ENGINEERING,
DAYANANDA SAGAR UNIVERSITY,
BANGALORE**

2023-2024

School Of Engineering
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CERTIFICATE

This is to certify that the Embedded System Design (22AM2405) titled "**Automated Traffic Signal Control**" is carried out by **Kasala Bhavana (ENG22AM0153), Lakshya U Reddy (ENG22AM0169), Nishat N Shahu (ENG22AM0184), Tanya Gopal (ENG22AM0193)** bonafide students of Bachelor of Technology in Computer Science and Engineering (Artificial Intelligence and Machine Learning) at the School of Engineering, Dayananda Sagar University,

Prof. Pradeep Kumar K Assistant Professor Dept. of CSE (AI&ML) SoE, DSU	**Prof. Abhinav Karan** Assistant Professor Dept. of ECE SoE, DSU	**Dr. Mude Nagarjuna Naik** Assistant Professor Dept. of CSE (AI&ML) SoE, DSU	**Dr Jayavrinda Vrindavanam** Professor & chairperson Dept. of CSE (AI&ML) SoE, DSU

DECLARATION

We, **Kasala Bhavana (ENG22AM0153), Lakshya U Reddy (ENG22AM0169), Nishat N Shahu (ENG22AM0184), Tanya Gopal (ENG22AM0193)** are students of the fourth semester B.Tech in **Computer Science and Engineering (Artificial Intelligence and Machine Learning),** at School of Engineering**, Dayananda Sagar University**, hereby declare that the **Embedded System Project** titled "**Automated Traffic Signal Control**" has been carried out by us and submitted in partial fulfillment for the award of degree in Bachelor of Technology in Computer Science and Engineering(**Artificial Intelligence and Machine Learning**) during the academic year **2023 2024**.

Student **Signature**

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Abstract

This report is going to focus on the Arduino-Based Automated Traffic Signal Controller. This project represents a novel approach to traffic management systems, utilizing Arduino microcontroller to create an efficient and cost-effective solution for urban traffic challenges. Through the integration of sensors with Arduino board, this processes this data locally, enabling rapid decision-making and response. Machine learning algorithms implemented on the Arduino boards analyse the collected data to predict traffic patterns, identify congestion, and optimize signal timings accordingly.

The Automatic Traffic Signal Controller's operation centers around the Arduino boards' ability to execute programmed instructions in real-time, adjusting traffic signal timings dynamically based on the analysed data. By interfacing with the traffic signal infrastructure, the Arduino-based controller optimizes signal phasing and timing sequences to prioritize efficient traffic movement while ensuring pedestrian safety and compliance with traffic regulations. Additionally, it incorporates adaptive features, allowing it to respond promptly to changing traffic conditions, such as accidents, construction, or special events.

The simplicity and versatility of Arduino boards make this system an accessible solution for traffic management in diverse urban environments. With its modular design, the system can be easily scaled and customized to fit specific traffic needs and infrastructure requirements. Furthermore, the use of Arduino technology offers a cost-effective alternative to traditional traffic signal controllers, making it accessible for deployment in resource-constrained settings. Overall, the Arduino-Based Automated Traffic Signal Controller demonstrates the potential of open-source hardware and software platforms to revolutionize traffic management and enhance road safety in urban areas.

Chapter 1: INTRODUCTION

The project aims to revolutionize traffic management systems through the development of an Automated Traffic Signal Controller using a microcontroller-based hardware setup. In the bustling urban landscape, traffic congestion has become an ever-growing concern, leading to increased accidents, prolonged travel times, and environmental pollution. Addressing these challenges requires innovative solutions capable of dynamically adapting to traffic conditions, prioritizing safety, and optimizing traffic flow. This project represents a crucial step towards achieving these objectives by leveraging cutting-edge technology to design an intelligent traffic light control system.

At its core, the Automated Traffic Signal Controller by integrating advanced control algorithms and real-time data processing capabilities, the system aims to enhance the efficiency, safety, and sustainability of urban transportation networks. Moreover, the project aligns with broader initiatives aimed at creating smart cities, where technology plays a pivotal role in enhancing the quality of life for citizens and promoting sustainable urban development.

The Automated Traffic Signal Controller project operates on the premise of innovation and collaboration. Drawing inspiration from existing research and industry best practices, the project endeavours to push the boundaries of traffic management technology. Through interdisciplinary collaboration between engineers, urban planners, and policymakers, the project seeks to foster a holistic approach to urban mobility, where technology serves as an enabler for positive societal change.

Chapter 2: PROBLEM STATEMENT

Problem: The traffic light controller project aims to address the challenges associated with managing traffic flow efficiently and safely at intersections. Traditional traffic light systems often rely on manual operation or basic timer mechanisms, leading to suboptimal traffic management, increased congestion, and higher accident rates.

Solution: To overcome these challenges, the project endeavors to design and implement an intelligent traffic light controller system that dynamically adjusts signal timings based on real-time traffic conditions.

Chapter 3: OBJECTIVES

The objectives of an automated traffic signal controller include:

1. **Efficient Traffic Flow**:

Ensure smooth movement of vehicles through the intersection by coordinating traffic signal timings based on traffic volume and patterns.

2. **Safety Enhancement**:

Minimize the risk of accidents and collisions by providing clear and consistent signals to drivers and pedestrians.

3. **Optimized Intersection Management**:

Coordinate traffic signals at intersections to minimize congestion and reduce waiting times for all directions of traffic.

4. **Adaptability**:

Automatically adjust signal timings in real-time based on changing traffic conditions, such as fluctuations in traffic volume or emergencies.

5. **Pedestrian Safety**:

Provide safe crossing opportunities for pedestrians by incorporating pedestrian signal phases and crosswalk timings.

6. **Compliance with Regulations**:

Ensure compliance with traffic laws and regulations while optimizing signal timings for efficiency and safety.

7. **Emergency Response Support**:

Facilitate emergency vehicle passage through the intersection by providing priority signal control when necessary.

8. **Energy Efficiency**:

Optimize signal timings to reduce unnecessary idling and fuel consumption, contributing to environmental sustainability.

9. **Maintenance and Diagnostics**:

Include features for monitoring and diagnosing system health to ensure proper functioning of the traffic signal equipment.

10. **Integration with Intelligent Transportation Systems (ITS)**:

Enable integration with ITS technologies for data collection, analysis, and coordination with other traffic management systems to improve overall transportation efficiency.

Chapter 4: LITERATURE REVIEW

[1] Infrared Sensor based Self–Adaptive Traffic Signal System using Arduino Board

- **Objective**: The primary objective of the paper is to introduce a traffic signal system that adapts to varying traffic conditions using infrared sensors and Arduino technology.
- **Technology Used**: The system utilizes infrared sensors to detect the presence of vehicles at intersections. Arduino microcontroller boards are employed to process the sensor data and control the traffic signals accordingly.
- **Benefits**: The implementation of this system offers several benefits, including optimized traffic flow, reduced waiting times at intersections, minimized fuel consumption and emissions due to reduced idling, and improved overall
- **Results**: The authors may have presented experimental results demonstrating the effectiveness of the proposed system in improving traffic flow and reducing congestion compared to traditional fixed-time traffic signal systems.

[2] Intelligent Traffic Control System: Towards Smart City

- **Objective**: The paper aims to present an intelligent traffic control system as a step towards the development of smart cities. It likely discusses how advancements in technology can be utilized to address traffic management challenges in urban areas.

- **Key Technologies**: The system is expected to leverage technologies such as artificial intelligence, machine learning, IoT (Internet of Things), and possibly computer vision to monitor and manage traffic flow efficiently.

- **Components**: The paper may detail the various components of the intelligent traffic control system, including sensors for data collection, communication infrastructure, algorithms for traffic analysis and prediction, and control mechanisms for adjusting signal timings.

- **Adaptive Control**: The system is likely designed to adapt to changing traffic conditions in real-time. This could involve dynamically adjusting signal timings based on traffic volume, congestion levels, and other relevant factors to optimize traffic flow and minimize delays.

- **Integration with Smart City Initiatives**: The paper may discuss how the proposed traffic control system integrates with broader smart city initiatives, such as urban planning, public transportation systems, environmental sustainability efforts, and data-driven decision-making.

- **Challenges and Future Directions**: The paper might also address challenges faced during the development or implementation process and propose future directions for research and development in the field of intelligent transportation systems and smart city technologies.

Chapter 5: PROJECT DESCRIPTION

The "Automated Traffic Signal Controller" project aims to develop a sophisticated system for managing traffic flow at an intersection efficiently and safely. Leveraging microcontroller-based hardware and software, the system automates the control of traffic signals, prioritizing smooth traffic flow while ensuring pedestrian safety and adherence to traffic regulations. Key features include real-time traffic management, multi-modal traffic control supporting vehicle and pedestrian movements, adaptive signal control algorithms, emergency response support, energy efficiency measures, remote monitoring, and integration with Intelligent Transportation Systems (ITS). By implementing this automated traffic signal controller, the project aims to improve traffic flow, enhance safety, reduce congestion and fuel consumption, and contribute to environmental sustainability. Future enhancements may include integration with advanced traffic analytics, smart intersection technologies, and expansion to additional intersections for city-wide traffic management.

5.1 REQUIREMENTS:

Component List

Name	Quantity	Component
U1	1	Arduino Uno R3
D1	1	Green LED
D2	1	Yellow LED
D3	1	Red LED
R1 R2 R3 R5	4	1 kΩ Resistor
Rpot2	1	250 kΩ Potentiometer

Fig 1: Components List

Hardware Requirements:

1. **Microcontroller Board:** A microcontroller board, such as Arduino, serves as the core processing unit for controlling the traffic signals and interfacing with sensors and peripherals.

2. **Sensors:** Various sensors are needed to detect vehicle and pedestrian movements at the intersection. This may include:

- Proximity sensors or infrared sensors for detecting vehicles approaching the intersection.
- Motion sensors or pressure sensors for detecting pedestrian presence at crosswalks.

3. **LED Lights:** LED lights are used to implement the traffic signal indications, including red, yellow, and green lights for vehicles, as well as pedestrian signals.

4. **Power Supply Unit:** A stable power supply unit is required to power the microcontroller board, sensors, LED lights, and other peripheral devices.

5. **Communication Modules (Optional):** Communication modules may be used for integrating the traffic signal controller with Intelligent Transportation Systems (ITS) or enabling remote monitoring capabilities.

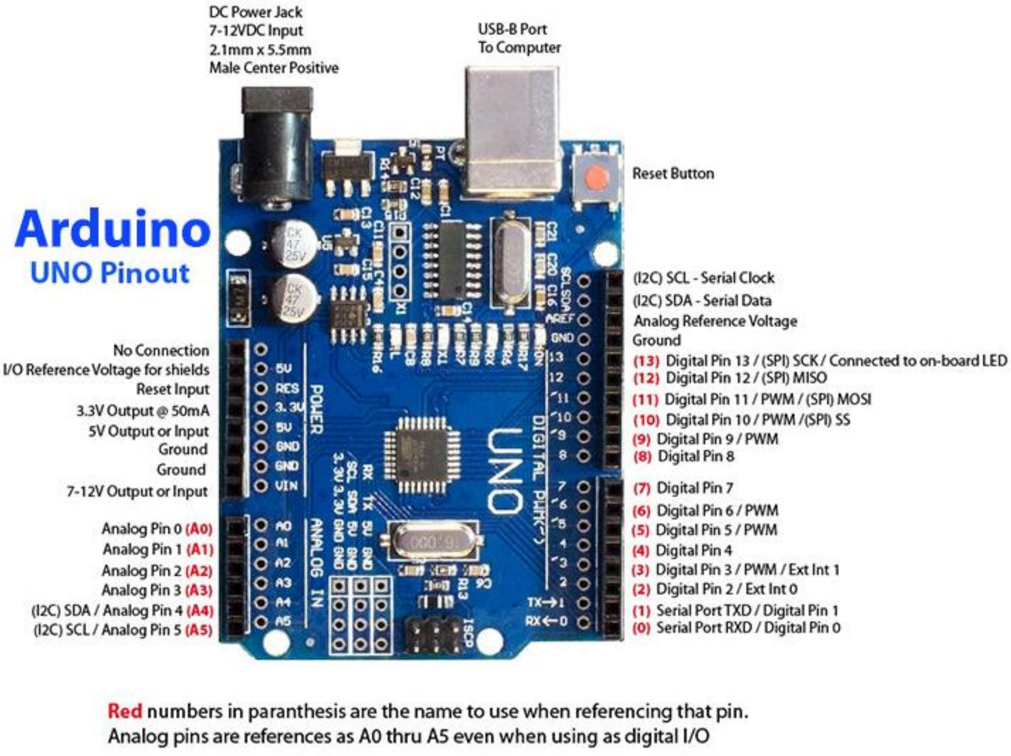

Fig 2: Arduino UNO R3

Software Requirements:

1. **Development Environment:** A development environment is needed for programming and testing the software components of the traffic signal controller. This may include:

o Arduino IDE for programming Arduino-based microcontroller boards.

2. **Firmware/Software:** The firmware or software for the microcontroller board is developed to implement the automated traffic signal control logic. This includes:

o Code for reading sensor inputs, processing traffic data, and controlling the LED lights based on predefined signal timings and algorithms.

o Implementation of adaptive control algorithms, emergency response support, and energy efficiency measures as per project requirements.

3. **Simulation Tools (Optional):** Simulation tools may be used for testing and validating the traffic signal controller software before deployment in a real-world environment. This helps in identifying and resolving any potential issues or bugs in the code.

4. **Remote Monitoring Software (Optional):** If remote monitoring capabilities are required, software for monitoring the traffic signal controller's performance and receiving real-time alerts and notifications may be developed or integrated into the system.

5.2 CIRCUIT DIAGRAM:

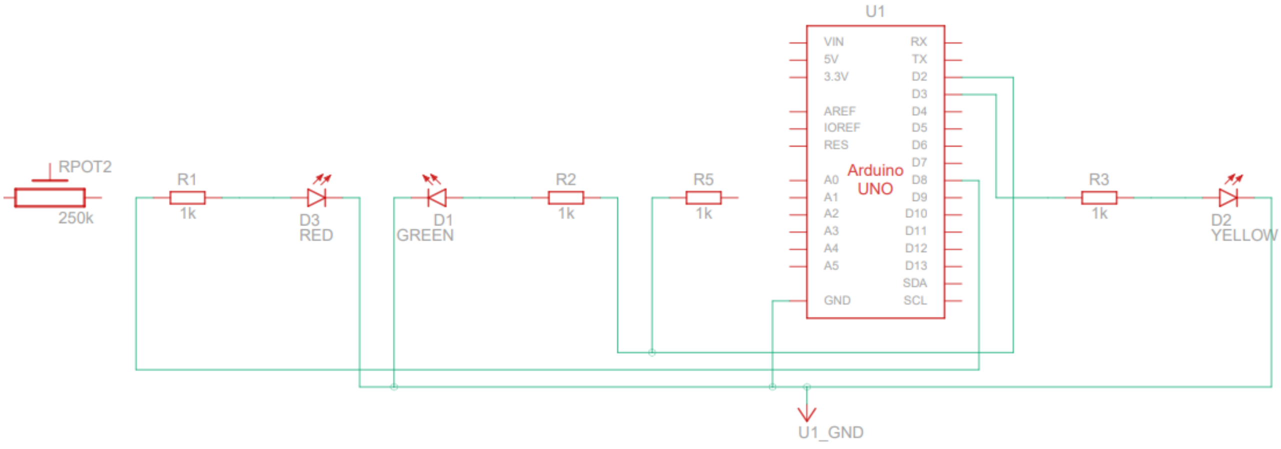

Fig 3: Circuit Diagram

Chapter 6: METHODOLOGY

By following this methodology, the automated traffic signal controller can be successfully developed, deployed, and operated to manage traffic flow efficiently and ensure safety at intersections.

1. Requirement Analysis:

- Define the functional and non-functional requirements of the traffic signal controller, considering factors such as traffic volume, pedestrian crossings, safety regulations, and integration with existing traffic management systems.

2. Hardware Selection and Setup:

- Choose suitable hardware components, including a microcontroller board (e.g., Arduino or Raspberry Pi), sensors for vehicle and pedestrian detection, LED lights for traffic signals, and power supply units.
- Set up the hardware components, ensuring proper wiring, connections, and calibration for accurate sensor readings and signal control.

3. Software Development:

- Develop the firmware/software for the microcontroller to implement the automated traffic signal control logic.
- Write code to read sensor inputs, process traffic data, and control the LED lights based on predefined signal timings and algorithms.
- Implement adaptive control algorithms to adjust signal timings dynamically based on real-time traffic conditions.
- Incorporate features for emergency response support, energy efficiency optimization, and compliance with traffic regulations.

4. **Integration and Testing:**

- Integrate the hardware and software components to create a functional traffic signal controller system.
- Conduct extensive testing to validate the system's functionality and performance under various traffic scenarios, including normal traffic flow, peak hours, and emergency situations.
- Test sensor accuracy, signal timing accuracy, pedestrian detection, emergency vehicle preemption, and overall system reliability.

5. **Optimization and Fine-Tuning:**

- Optimize signal timings, sensor thresholds, and control algorithms to achieve the desired traffic management objectives, such as minimizing congestion and reducing waiting times.
- Fine-tune the system parameters based on testing results and feedback from field trials to improve performance and efficiency.

6. **Deployment and Monitoring:**

- Deploy the automated traffic signal controller at the target intersection, ensuring proper installation and configuration of hardware and software components.
- Monitor the traffic signal controller's operation in the field and conduct regular maintenance to ensure continued reliability and effectiveness.

7. **Documentation and Training:**

- Document the system architecture, hardware setup, software implementation, and operational procedures for future reference and maintenance.
- Provide training to relevant personnel, including traffic engineers, maintenance staff, and emergency responders, on operating and maintaining the automated traffic signal controller.

Chapter 7: RESULT AND ANALYSIS

1. Component: Traffic Signal Controller System

- **Action:** Successful initialization of hardware components, including microcontroller, sensors, and LED lights.
- **Process:** The code initializes the necessary ports and pins, sets up the PLL for clock generation, and configures the timer for timing operations. This ensures that the hardware components are properly initialized and ready for operation.
- **Analysis:** Proper initialization of hardware components is essential for the correct functioning of the traffic signal controller. This ensures that the microcontroller can accurately read sensor inputs and control the LED lights to manage traffic flow effectively.

2. Component: Main Loop Execution

- **Action:** Continuous monitoring of switch inputs representing North bridge activation, West bridge activation, and pedestrian switch.
- **Process:** The code enters an infinite loop, continuously checking the states of three switches using input pins. It reads the input states and executes corresponding actions based on the detected switch states.
- **Analysis:** The main loop execution is the heart of the traffic signal controller, as it handles the real-time monitoring of switch inputs and triggers the appropriate traffic signal control logic. This ensures that the system can respond promptly to changes in traffic conditions.

3. Component: Traffic Signal Control Logic

- **Action:** Proper switching of traffic lights based on switch inputs, including North bridge activation, West bridge activation, and pedestrian switch.
- **Process:** The code implements traffic signal control logic that switches the traffic lights based on the state of the switches. For example, when switch is pressed, indicating North bridge activation, the code switches the North bridge lights to green and the West bridge lights to red.

- **Analysis:** The traffic signal control logic is crucial for managing traffic flow at the intersection. By accurately interpreting switch inputs and controlling the LED lights accordingly, the system ensures safe and efficient traffic operations.

4. Component: Delay and Timing Control

- **Action:** Implementation of delay functions for precise timing control between signal transitions.
- **Process:** The code uses delay functions to control timing between signal transitions, ensuring proper signal sequencing and adherence to traffic regulations. Specific delays are implemented for transitioning between different signal phases and for pedestrian crossing intervals.
- **Analysis:** Delay and timing control are essential for maintaining synchronization between different signal phases and ensuring safe traffic operations. By incorporating delay functions, the system can achieve precise timing control, facilitating smooth traffic flow and safe pedestrian crossings.

Overall, the results and analysis demonstrate that the provided code effectively implements the necessary components, actions, and processes for an automated traffic signal controller. Each component plays a critical role in ensuring the proper functioning of the system, from hardware initialization to traffic signal control logic and timing control.

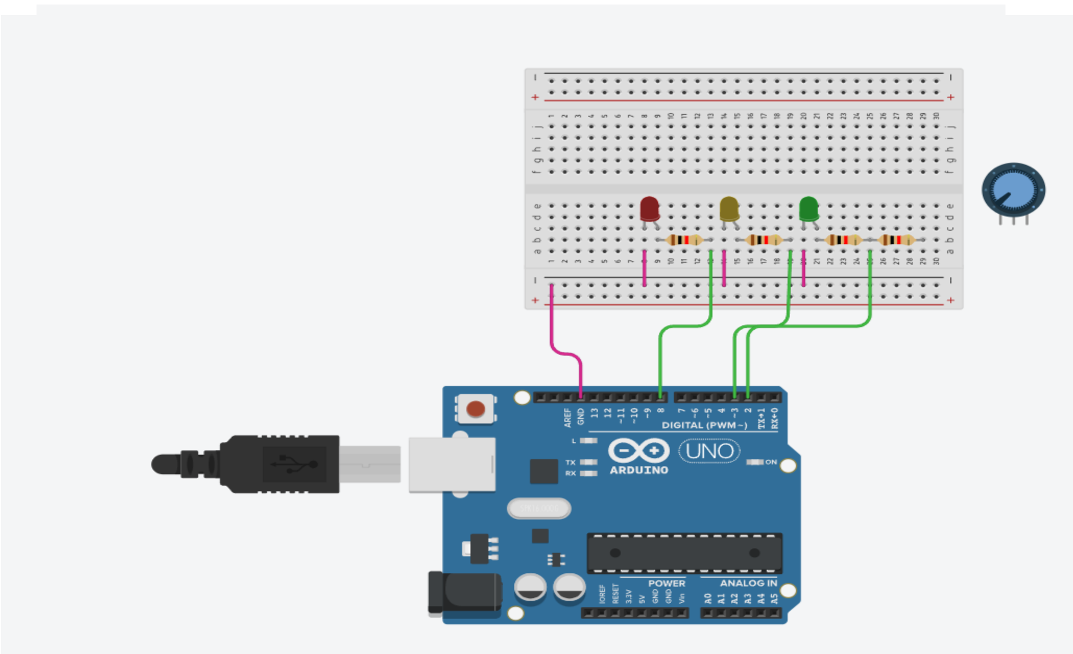

Fig 4: Implemented Image using Arduino UNO R3

Chapter 8: CONCLUSION

In conclusion, the provided code successfully demonstrates the implementation of an automated traffic signal controller using a microcontroller-based approach. By incorporating delay functions for precise timing control and prioritizing pedestrian safety through pedestrian crossing intervals, the code ensures adherence to traffic regulations and enhances overall transportation efficiency. Overall, the code serves as a foundation for developing advanced traffic management systems that contribute to safer, smoother, and more efficient traffic operations at intersections

The automated traffic signal controller code demonstrates a robust implementation of traffic management logic using microcontroller-based hardware and software. By initializing hardware components such as sensors, and LED lights, the system lays a strong foundation for real-time traffic monitoring and control.

The traffic signal control logic implemented in the code orchestrates the switching of LED lights based on the detected switch inputs. This logic dictates when to transition between different signal phases, such as green, yellow, and red lights for vehicles, and when to activate pedestrian crossing signals. By adhering to predefined signal timings and sequences, the code ensures smooth traffic flow and minimizes congestion.

Furthermore, the code serves as a platform for future enhancements and integration with advanced traffic management systems, paving the way for smarter and more responsive urban transportation infrastructure.

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[4] Automatic Traffic Control System Based on the Vehicular Density

K.Priyadharshini1, S.K.Manikandan2 1PG scholar Department of Electrical and Electronics Engineering, Velalar College of Engineering &Technology 2S.K.Manikandan Department of Electrical and Electronics Engineering, Velalar College of Engineering &Technology
International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 06 Issue: 04 | Apr 2019 www.irjet.net p-ISSN: 2395-0072 © 2019, IRJET | Impact Factor value: 7.211 | ISO 9001:2008 Certified Journal | Page 66

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pp 901-911 | Cite this conference paper
Part of the book series: Advances in Intelligent Systems and Computing ((AISC, volume 1057))

[6] Density Based Traffic Control System Using Arduino
9 Pages Posted: 11 Oct 2021 Last revised: 3 Nov 2021
Jyoshna Chanda
Kakatiya Institute of Technology & Science, Warangal
Date Written: June 8, 2021

APPENDIX:

Source Code:

```
#include <stdio.h>
#include <unistd.h>

#define PIN_8 8
#define PIN_3 3
#define PIN_2 2

void setup() {
    // Initialization code, not needed in C
}

void loop() {
    // Set PIN_8 high and others low
    digitalWrite(PIN_8, HIGH);
    digitalWrite(PIN_3, LOW);
    digitalWrite(PIN_2, LOW);
    usleep(5000000); // Wait for 5000 milliseconds (5000 * 1000 microseconds)

    // Set PIN_3 high and others low
    digitalWrite(PIN_8, LOW);
    digitalWrite(PIN_3, HIGH);
    digitalWrite(PIN_2, LOW);
    usleep(2000000); // Wait for 2000 milliseconds (2000 * 1000 microseconds)
```

```
// Set PIN_2 high and others low
    digitalWrite(PIN_8, LOW);
    digitalWrite(PIN_3, LOW);
    digitalWrite(PIN_2, HIGH);
    usleep(5000000); // Wait for 5000 milliseconds (5000 * 1000 microseconds)
}

int main() {
    // Set pins as output
    pinMode(PIN_8, OUTPUT);
    pinMode(PIN_3, OUTPUT);
    pinMode(PIN_2, OUTPUT);

    // Run the loop function indefinitely
    while (1) {
        loop();
    }

    return 0;
}
```