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DENSITY BASED SMART TRAFFIC CONTROL AND MANAGEMENT SYSTEM

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Abstract : Vehicular traffic at intersecting streets is typically controlled by traffic control lights. To ensure that traffic moves as smoothly and safely as possible, traffic lights require sophisticated control and coordination. Congestion in traffic is a serious problem nowadays. The traffic congestion can be caused by large red light delays, accidents, and stuck vehicles in cross-lock situations from the nearby sides due to frequent transitions of lights viz. green to red light and vice versa. Conventionally, the delay of each light is hardcoded in the traffic light and is not dependent on traffic. This calls for a need to develop a system that can optimize the delay when the traffic increases. This paper presents a density-based traffic light control and monitoring system. The system attempts to reduce the likelihood of traffic jams, caused by traffic lights, to an extent. The system is based on an MCS-51 family-based AT89S52 microcontroller. The system consists of an infrared (IR) transmitter and a receiver that are mounted on opposite sides of the road. The IR system is controlled by a microcontroller, which also monitors the number of vehicles on the road. The microcontroller makes a decision based on the density of the vehicle count and updates the traffic light delays as a result. The traffic light is placed a certain distance away from the IR system. Thus based on vehicle count, the microcontroller defines different ranges for traffic light delays and updates those accordingly. Traffic conditions on any approachable traffic signals and neighboring roads can be accessed by an administrator on a central station computer, allowing traffic congestion to be reduced to some extent.

***IndexTerms* – Density based, traffic light, traffic control, congestion control.**

I. Introduction

Congestion is a major issue in many modern cities around the world. Many critical problems and challenges have arisen as a result of traffic congestion in the world's most populous cities. To travel to different places within the city is becoming more difficult for the travelers in traffic. People lose time, miss opportunities, and become frustrated as a result of traffic problems. Traffic congestion directly impacts the companies. Due to traffic congestions, there is a loss in productivity from workers, trade opportunities are lost, delivery gets delayed, and thereby the costs go on increasing.

To solve these congestion problems, we have to build new facilities & infrastructure but at the same time make it smart. The only disadvantage of making new roads on facilities is that it makes the surroundings more congested. So for that reason, rather than building new infrastructure twice, we must change the system. As a result, many countries are working to improve the mobility, safety, and traffic flow of their existing transportation systems to reduce the demand for vehicle use. There are mainly three reasons contributing to congestion. Firstly, the traffic flow increases during peak hours that too sometimes in a particular direction only. There is usually dense traffic from cities to the outskirts and in the reverse direction from Monday to Fridays respectively. Secondly, the traditional traffic light system has schemed with hardcoded delayed where the lights changing interval time is fixed at a predetermined period of each direction of the traffic flow. It does not rely upon the ongoing volume of the traffic stream. Thirdly, the condition of a single light at a junction affects the traffic flow at the nearby junction. Likewise, the traditional traffic system does not consider various conditions such as accidents, roadwork, and vehicle breakdowns that contribute to a worsened traffic congestion, which then has a significant negative impact on emergency vehicles.

This paper presents a significant approach to overcome this congestion due to traffic by replacing the hardcoded delay with an adaptive delay according to the traffic density in a particular lane. A prototype design of a smart traffic control and management system is proposed to overcome the losses which may occur when emergency vehicles of higher priorities such as ambulances, rescue vehicles, fire service, and police cars. In addition to the above, pedestrians who are crossing the roads are likely to be a contributing factor too. A new traffic light control system is required so that high priority vehicles such as ambulances, rescue vehicles, fire service, and police cars do not get stuck in severe traffic and can save lives during emergencies.

II. Literature Review

The conventional traffic lights in use today are not smart, and they use fixed delays to change the lights for the various road users waiting in different lanes. They cannot even take any measures when an emergency vehicle is stuck in between the lane. Several research works have been carried out for the traffic control system to prioritize the transit of emergency vehicles and organize traffic flows at intersections. Sundar et al. [1], Sireesha and Rakesh [2], Shruthi and Vinodha [3], and Hussain et al. [4] proposed intelligent traffic management technologies that give priority to emergency vehicles. Kapileswar and Babu [5] used cameras to measure traffic conditions at intersections, which were then used to estimate traffic light sequences. To detect the presence of emergency vehicles and determine real-time traffic density, Shaikh and Chandak [6] used contemporary technology such as infrared cameras and global positioning services (GPS). Bharadwaj et al. [7] used radio frequency identification (RFID) tags to identify the presence of emergency vehicles and the inductive loop approach to count them. Al-Ostath [8] and Mittal and Bhandari [9] proposed emergency vehicle presumption techniques in which sensors were installed at each intersection to detect the presence of emergency vehicles. The traffic light controller then flashed a green light toward an emergency vehicle until it exited the intersection. Hegde et al. [10] proposed an RFID and GPS-based automatic lane clearance protocol for ambulances. The goal of this protocol was to reduce ambulance travel times by clearing lanes before an ambulance arrived at an intersection. Atta et al. [11] used RFID readers, labels, and the Internet of Things (IoT) enabled sensors-based fuzzy system for dynamic timings of traffic signals and sensing the density of traffic to minimize the congestion. Balu and Priyadarshini [12] make use of image processing techniques to find the density of the vehicles and their count to manage the time slot of green and red signals. Shenbagavalli et al. [13] designed a traffic light control system for emergency vehicles implemented using wireless communication radio frequency (RF) and Programmable Integrated Circuit (PIC) Arduino microcontroller. Nithya and Miniyadan [14] tried to maximize traffic throughput and minimize average vehicle waiting times at intersections by making use of IoT based platform. Nwosu et al. [15] utilized Global System for Mobile communications (GSM) along with three PIC 16F877A microcontrollers to design a prototype for density based traffic light system. Kirubakaran et al. [16] proposed a smart traffic signal control system based on video processing technique based on Rasberry pi.

All these research works presented suggested complicated mechanisms to suggest measures for managing the traffic and controlling congestion to some extent. However, when it comes to installing these methods, they are found to be practically very expensive and require too complex engineering knowledge. This has become the main motivation to write this paper as our proposed model will determine the junction density using simple infrared (IR) sensors, installed on each side of the lane and interfaced with the microcontroller to reduce the congestion and clear the traffic.

III. PROPOSED METHODOLOGY

A smart traffic light control and management system intended for smart allocation of passing through traffic lights is planned. IR sensor pairs are installed in each direction at far distances from the traffic junctions. There can be multiple sets of IR pairs in each direction to determine the density of the vehicles. The outputs of all the sensors on a single side will be used together to identify the crowd on that particular side. Rx, Yx, and Gx denote the traffic lights in x-direction respectively, where x takes the values as 1,2,3,4 corresponding to all four directions. Refer to Fig. 1 for such arrangements.

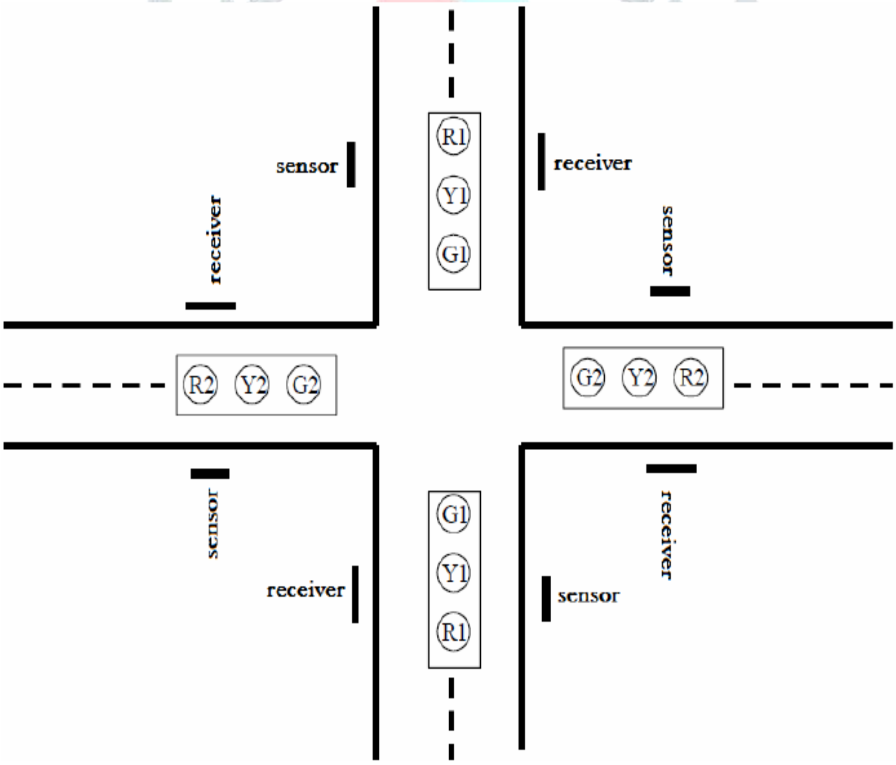

Fig.1: General Arrangement of sensors

All the IR sensor pairs on each side are connected with an 8-bit microcontroller AT89S52 to monitor the status of the sensors. The basic block diagram of the prototype is shown in Fig. 2.

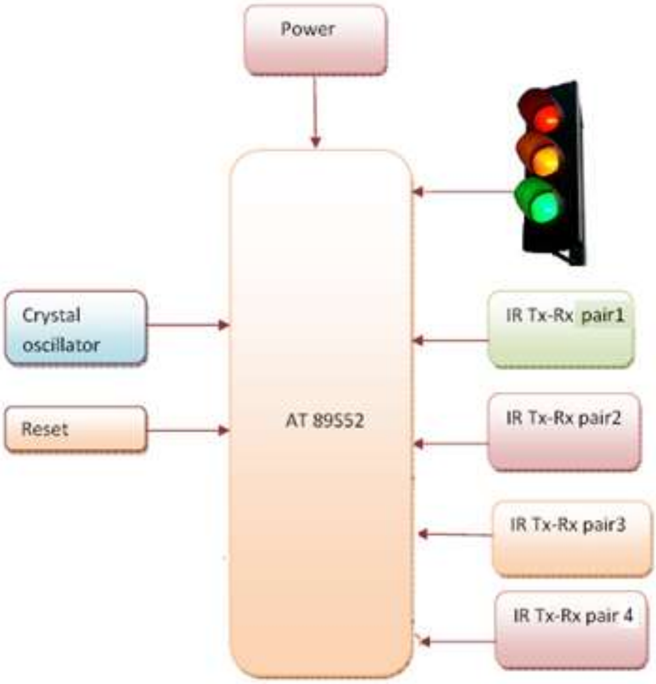

Fig. 2: Block Diagram of the Prototype

This prototype model uses simple electronic components such as LEDs as traffic light indicator and a microcontroller is used for auto change of the signal. In normal scenarios, the lights get change in pre-specified time intervals programmed in the microcontroller usually 30 seconds of Green light in the clockwise direction to clear traffic on all the sides in a sequential manner. Microcontroller AT89S52 is the brain of the project which initiates the traffic signal at a junction. The led's are automatically on and off by making the corresponding port pin of the microcontroller high. At a particular instant, only one green light holds and other lights hold at red. During the transition from green to red, the present group yellow led and succeeding group yellow led glows, and then succeeding group led changes to green. This process continues as a cycle. However, in case if traffic at any of the sides increases beyond the acceptable limit and extends till the IR sensors are mounted. The IR sensor pairs get enabled in that direction and signal the microcontroller about the density of the traffic. Consequently, according to the level of traffic, the microcontroller extends the time duration of Green light of that lane to maintain the traffic in acceptable limits. Thus by minimizing the transitions of light from Red to Green by changing the ON time of Green light in any particular direction will help in overcoming the congestion autonomously.

IV. Circuit Modeling

This section deals with the details of the circuit used to design and test this prototype.

4.1Power Supply

The power supply is the major concern for every electronic device. Since the controller and other devices used are low power devices there is a need to step down the voltage and as well as rectify the output to convert the output to a constant dc. The block diagram of the regulated power supply is as shown in Fig. 3.

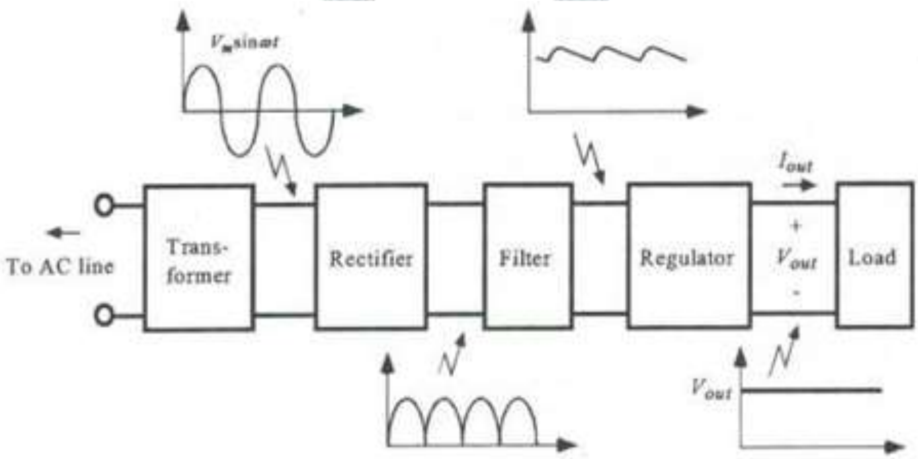

Fig. 3: Components of a typical linear power supply

Fig. 4 shows the detailed circuit diagram of the power supply. As this model operates on a regulated 5V DC power supply a step-down transformer of 230/12-0-12 V is used before the full-wave bridge rectifier to bring the power levels down from 230V AC to 12V DC. This supply is then fed to 5V voltage regulator IC 7805 which converts the voltage to constant 5V and releases the remaining power in terms of heat.

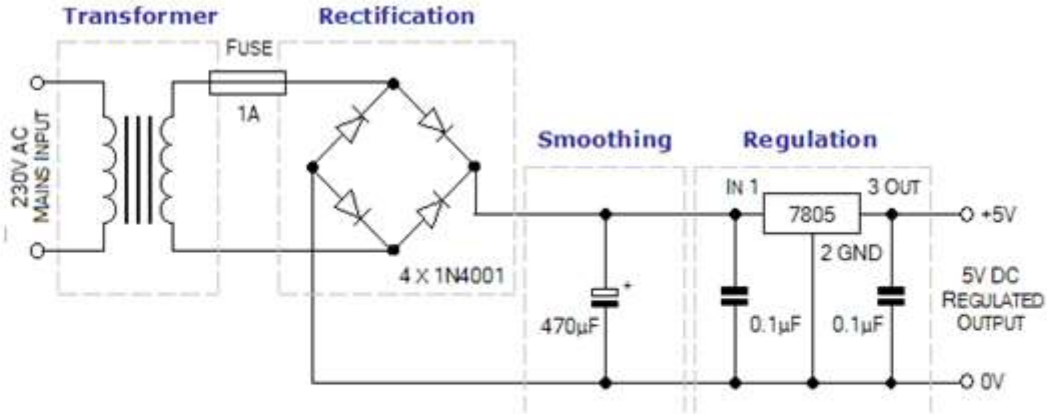

Fig. 4: Circuit Diagram of Power Supply

4.2 Microcontroller Control and Display Section

The microcontroller circuit is the brain of the model. The basic control and display connections with microcontroller are shown in Fig. 5. The microcontroller receives the 11.0592MHz clock from the crystal oscillator at XTAL1 and XTAL2 pin. The reset switch connected at pin 9 of the microcontroller provides a manual reset of the microcontroller. Pull-up network resistance of 10K is provided at each leg of port pin P0 as it is required to properly differentiate between high and low TTL signals. And the pins of other ports P1, P2, and P3 are directly connected to peripherals as they are internally pulled up. LCD connected with its three control signals RS (Register Select), R/W (Read/Write), and E (Enable) is used to display the outputs and status messages for the user. Port P2 is used to provide data to LCD to display as a character. The remaining pins of Port P0, P1, and P3 are used to interface led representing traffic lights and IR sensor pairs in all four directions.

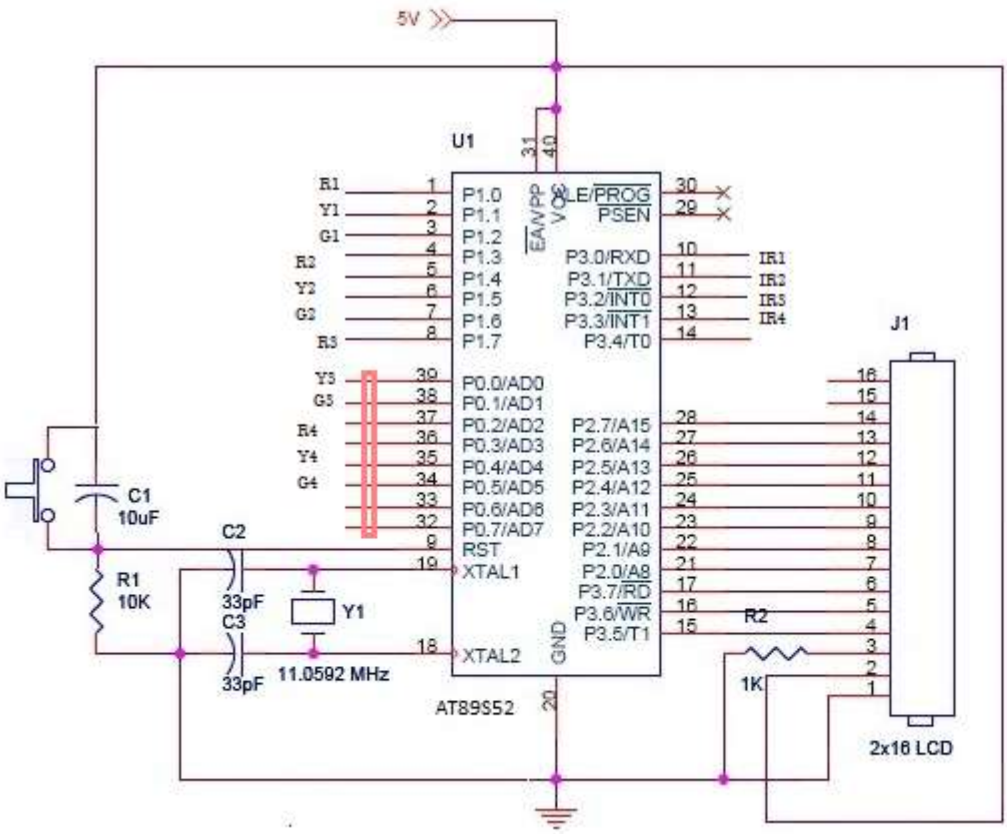

Fig. 5: Circuit diagram of microcontroller control and display

V. Results

The intelligent traffic light control and monitoring system were successfully operated as a result of the work. The IR sensor and transmitter are separated by a gap. A road is represented by a black strip in the prototype. As a stand-alone device, the system is put near a road. When a vehicle passes between the IR transmitter and the IR sensor, the microcontroller detects it and increases the number of vehicles counted in the recording interval for that traffic light. The traffic light is placed at some distance ahead of the IR sensor so that decisions taken by the microcontroller to control traffic lights can help in reducing the congestion at the traffic light.

The traffic light delays for the next recording interval are determined by the microcontroller based on the vehicle count. Traffic light delays are defined by monitoring the vehicle density. This delay can be varied as the density of vehicles increases or decreases. Fig. 6 shows the final prototype of the traffic light control model. A 16x2 LCD is used in the prototype for administrator/ traffic control room to monitor the status of traffic lights and commands send by the microcontroller to change the delay. The system values can also be stored for further analysis of traffic occurrences in a particular time or area.

Fig. 6: Final prototype of traffic light control model

VI. Conclusion And Future Scope

This paper has successfully presented an approach for the optimization of traffic light controllers in a city using IR sensors and microcontrollers. By using this system configuration the authors try to reduce the possibilities of traffic jams, caused by traffic lights, to an extent and we have successfully got the results. The number of passing vehicle in the fixed time slot on the road decide the density range of traffics and based on vehicle density microcontroller decide the traffic light delays for next recording interval. Administrator sitting on the computer can monitor the system to download recorded data, update light delays, erase memory, etc. As a result, an administrator on a central station computer can access traffic conditions at any approachable traffic light and nearby roads to alleviate traffic congestions to some extent. In the future, this system could be used to alert people to traffic conditions in various locations. Data transfer between the microcontroller and the computer can also be accomplished using a telephone network and a data call-activated SIM card. This technique will allow the operator to gather the recorded data from a far end to his home computer without going there. Traffic lights can be increased to N number and traffic light control can be done for the whole city by sitting in a single place.

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