ISSN 2347 - 3983
Volume 8. No. 10, October 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter1308102020.pdf
https://doi.org/10.30534/ijeter/2020/1308102020

Smart traffic management system with violation detection

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ABSTRACT

This paper proposes a Smart Traffic Management system based on the traffic density present across a four-way crossing using infrared sensors. Along with this, a battery charging circuit is designed to charge a battery using solar energy captured with the help of a solar panel. A Traffic Violation Detection circuit is also proposed which can detect the traffic rule violations by the vehicles during the red light. The circuit is precise, but at the same time simple enough to be implemented in a low-cost processor. The infrared sensors are used to detect the density of the vehicles in a particular lane. Once the traffic density in a lane is detected, the timing of the red and green light is then adjusted according to the data from the sensors. Whenever a traffic light violation is detected by Traffic Violation Detection circuit, the picture of the violator is captured and a SMS alert is generated and sent to the concerned authority.

Key words : Infrared sensors, Battery charging circuit, Traffic violation detection.

1. INTRODUCTION

Automotive technologies are gaining ground in modern traffic control system since the number of vehicles and passengers are rapidly growing so there is a need for safety critical traffic signal automation. Also, in today's world of energy crisis and global warming conventional sources of energy are not the solution. Alternative sources of energy, especially renewables ones have become vital to handle the problems due to energy crisis [1] [3] [4] [5]. Renewable sources of energy are obtained from naturally replenished sources. This paper explains a battery charging circuit that can charge a battery by harnessing solar energy.

It focuses on the problem of traffic management by creating a smart system which is able to handle the traffic based on the density of vehicles on a particular lane and at the same time it can be supported by solar energy for working [11] – [18].

Modern traffic control systems have three components: Detector, controller and signal display. The detector helps in detecting vehicles in lane and sends the data to the control system which may be automated or a manual system. Controller processes the data and then sends the signal to the output panels. The signal display directs the vehicles on the road whether to pass or stay [2].

The proposed system for traffic management uses IR sensors for detecting the traffic density in a particular lane. Based on the signal from the sensor, the microcontroller changes the duration of green light. The microcontroller used is 8051.To implement the use for green energy, a battery charging circuit is used which can charge a battery by harnessing solar energy using a solar panel [6] –[10]. This circuit operates only when there is a red-light signal for a particular lane. During the red light, vehicles are expected to stop. If someone tries to cross the red signal, then the circuit can detect the violation by using laser and LDR. This circuit requires the violator to break path of the laser which is falling on LDR. Once the path is broken, the LDR sends signal to buzzer which can alert the authority on site.

At the moment of violation, a picture of violator is captured while it is violating the red signal. Along with the picture, an SMS alert is generated and sent to the concerned authority.

The paper is organized as follows. Section 2 deals with the types of traffic management systems and explains the working of them. The control logic of the smart traffic system is explored in Section 3. In Section 4, the methods have been verified and discussed exhaustively. Section 5 concludes this paper.

2. CONVENTIONAL TRAFFIC MANAGEMENT AND DETECTION SYSTEMS

2.1 Types of Traffic Light Systems

There are different types of traffic management systems. Out of which the most widely employed is discussed in this section.

2.1.1 Traffic Management System with Fixed Time

In this method, signals will change in accordance with the preset timings. Signals will continue to repeat the cycle all the time even when there are no vehicles on the signal crossing.

2.1.2 Adaptive Traffic Light Systems

In this method, green time is allocated variably. It responds to traffic dynamically based on real time data of the changing traffic patterns (see Figure 1 b) [11]. Signals are generated based on input from vehicle detectors to a controller. The data

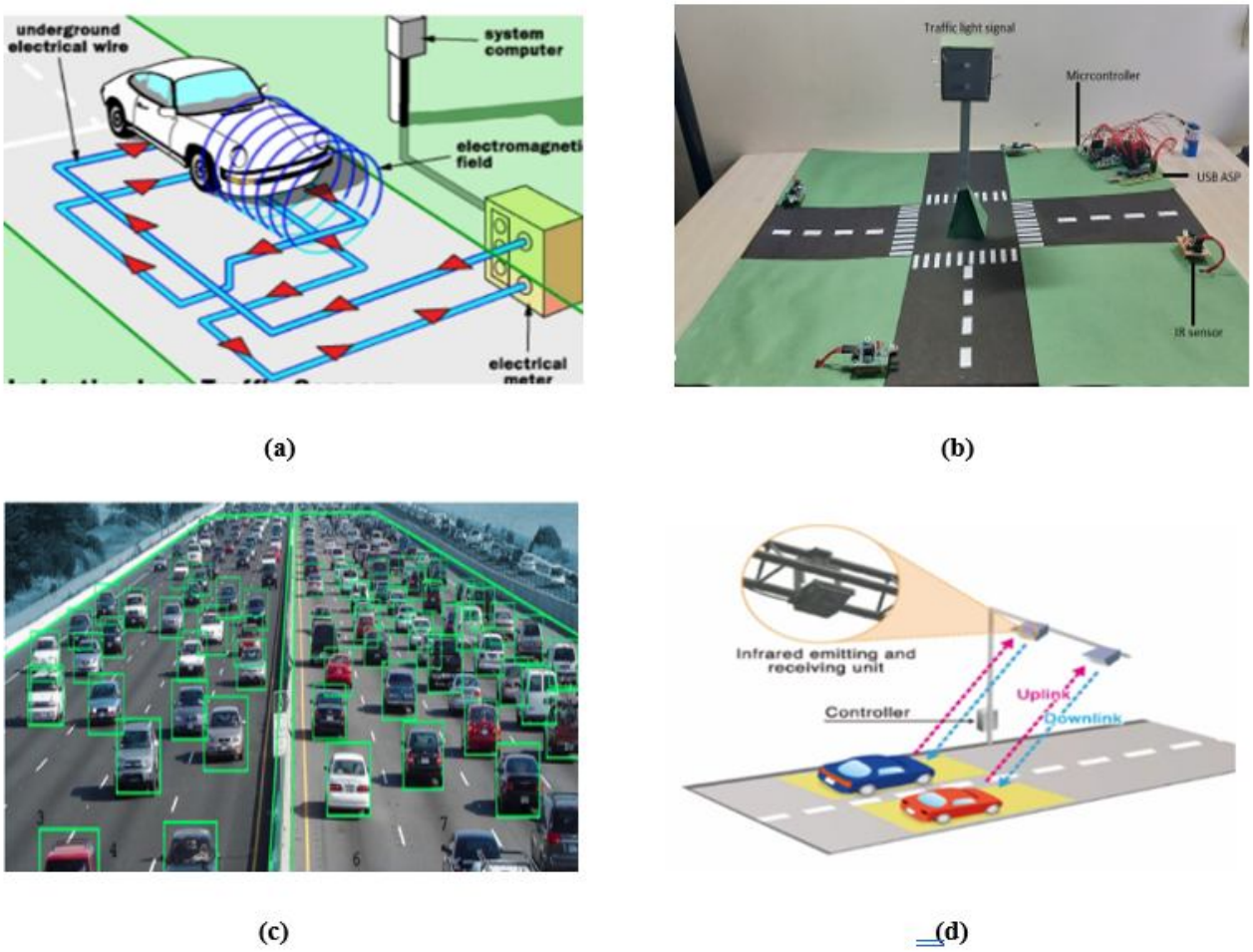

Figure 1. Types of detection systems (a) Induction loop traffic sensor, (b) Prototype of traffic light control system, (c) Video-Detection system and (d) IR detection

collected by the controller is sent to the central processing unit which calculates the density appropriately and allots the timings of the red and green signal based on the calculated density.

2.2 Types of Detection Systems

The various detection schemes are mentioned and discussed in this section. The implementation of these systems is discussed in further sections.

2.2.1 Inductive Loop

The loop is buried in the traffic lane and is used to generate magnetic field which is powered by the detector. When the vehicles cross the loop, the inductance of the circuit increases. Figure 1a describes this mechanism.

2.2.2 Video Detection

Images of moving traffic are captured using the surveillance cameras placed at different positions on the lane, the images are processed rapidly in real time hence providing traffic management effectively [20] – [27]. Figure 1 c shows the mechanism.

2.2.3 Radio Detection and Ranging

The IR detectors and optical receivers are installed just above the lanes. They detect vehicles by utilizing reflected waves of near infrared rays. The IR detection system consists of an infrared emitting and receiving unit. In this system, vehicles are detected when they reflect infrared waves back to the receiving unit of the IR detector [19]. These systems have shorter range than the RADAR detection system. Figure 1 d describes the IR detection mechanism.

3. PROPOSED SMART TRAFFIC CONTROL LOGIC

The density of the traffic at a crossing will be sensed with the help of Infrared sensor and then the timings of red and green light will be controlled accordingly to facilitate the ease of movement and to save people's time. To detect the signal breach by any vehicle, a traffic violation detection circuit is incorporated. If a vehicle crosses the line, then the picture of the violator is captured, a SMS alert is generated and sent to the concerned authority.

The components necessary for this circuit are 8051 microcontroller, a digital IR sensor, 8 core cables and connecting wires, red and green LEDs, resistors and a 9v battery and a battery cap. To supply power to the circuits, a 9V battery is used. Also, to recharge the battery we have designed a Battery charging circuit which uses solar energy to regenerate power in battery. Thereby we implement a system which is compatible with conventional as well as renewable energy and at the same time solves the real-world problem of Traffic management faced in day to life by reducing time at a signal by adaptive time controlling.

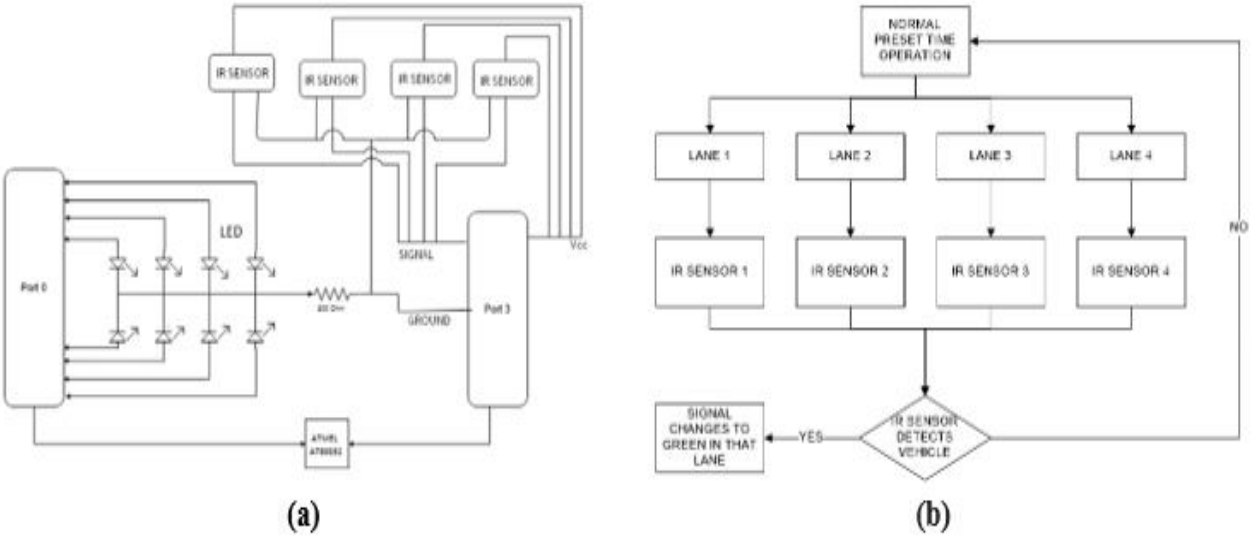

Figure 2. (a) Traffic light circuit and (b) Circuit and microprocessor flowchart

In the circuit shown in figure 2 a, IR sensors are used to sense the density of traffic at a crossing. The sensors are placed at a location in the lanes where presence of vehicle indicate that it is too crowded. Hence the sensor will detect the vehicle at that location and send the detected signal to the microcontroller.

The microcontroller will then enable the green light of the respective lane. In this way the lane which have maximum traffic will be allotted more time to let the vehicles pass. The flowchart shown in figure 2 b explains this process in detail.

3.1 Violation Detection System

The circuit shown in figure. 3 works in two stages

Stage 1: This circuit uses a Light Depended Resistor. The idea is to switch on or off the buzzer circuit, based on the resistance of the LDR. The resistance and the LDR, connected, between the buzzer and battery are used to form the potential divider network. Transistor is used here for switching purpose. Depending on the voltage across the LDR, the transistor switches ON or switches off the buzzer. If the voltage across the LDR lied above the cut-off value of the voltage (0.6V), the transistor gets switched ON which will turn the buzzer ON indicating breaking of laser path.

LDR registers low resistance values of the order of mΩs when it is exposed to the light. The value of the resistance is significantly higher of the order of MΩ when the light is not there in the surroundings. A LASER light is projected on the LDR. LASER light is used because it does not deviate from the projected path. When the laser is projected on the LDR, its resistance value is very low. Thus, in accordance with the ohm's law, the voltage across the LDR will also be low which will not be enough to switch ON the transistor, hence it remains OFF and as a result the buzzer does not operate.

Stage 2: Buzzer operation indicate that the traffic signal is violated by a vehicle. In the stage two, the picture of the vehicle is captured while it is violating the signal and at the same time an SMS alert is generated for the concerned authority.

The operation of buzzer is detected by the arduino. For this, an analog pin and the ground pin are connected in parallel with the buzzer. Once the buzzer operates, the voltage is read in arduino and if the detected voltage crosses a particular threshold, the GSM module is used to generate the

alert SMS. Also, a keyword is sent to python which directs the camera hardware to capture the image of the vehicle while it is violating the traffic signal, as shown in figure 5.

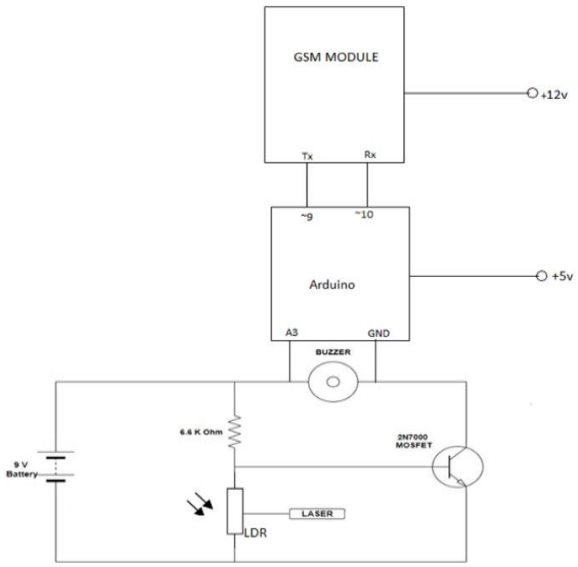

Figure 3. Traffic violation detection circuit

3.2 Solar Battery Charging Module

Solar power is harnessed directly through the use of photovoltaic cells that are used for the conversion of heat to electricity. They are made of semiconductor materials that

exhibit the photovoltaic effect. Solar power can be indirectly harnessed by using the concentration of sunlight to generate heat which is further used to increase the energy of a working fluid. The energized fluid is used to rotate the steam turbine which ultimately generates electrical power. For the concentration of sunlight at a particular point, mirrors and lenses are used.

The battery charging circuit is as illustrated in figure 4. This circuit uses 21V solar panel and a variable regulator IC LM317. Charging current from the solar panel passes through the D1 to IC LM317. By varying the adjust pin of the potentiometer, the current and V_o of the IC can be controlled. Resistor (R3) controls the current flowing from panel to the battery (charging current) and D2 prevents current from battery from slowing in opposite direction. Thus preventing discharge. LED1 is used to indicate the charging of battery. When battery voltage rises above 6.8 Volts, the Zener starts conducting and switches "ON" the transistor BC548 by supplying the base current. The transistor then short circuit the V_o pin with the ground to stop charging.

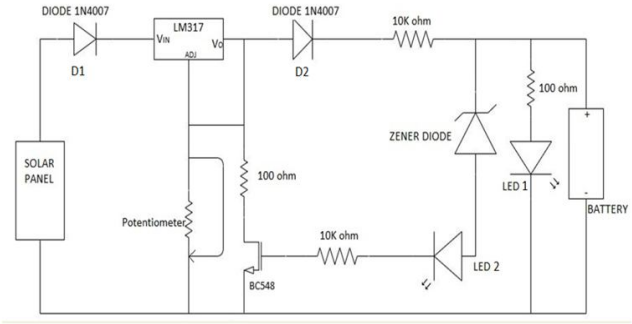

Figure 4. Battery charging circuit

4. RESULTS AND DISCUSSION

Traffic density is controlled by using the IR sensor by detecting the presence of vehicle and the correct results are obtained. The battery charging circuit designed in this paper is giving correct results by charging the battery. When the battery is charged then the power from the solar panel cuts off and thus prevent the battery from any damage. This leads to the safety of the battery. The traffic violation detection circuit implemented in this paper helps to catch people who are breaking the rule by crossing the signal. It works by taking a picture of the violator at the instant he crosses the red light as seen in figure 5 and 6. A Buzzer blows at the site to indicate the traffic police on the road and also it sends a SMS to the concerned authorities to catch the violator at the next signal.

Some of the constraints are the LDR used in the traffic violation detection circuit can get affected by the presence of surrounding light. Even if the density isn't high enough in a particular lane and a vehicle stops in front of the IR sensor, the green light will be activated. Some alternatives are that in place of LDR, IR sensors can be implemented to detect vehicles in the traffic violation detection circuit. Also, A raspberry pi can be used in the place of a computer for the operation of a surveillance camera.

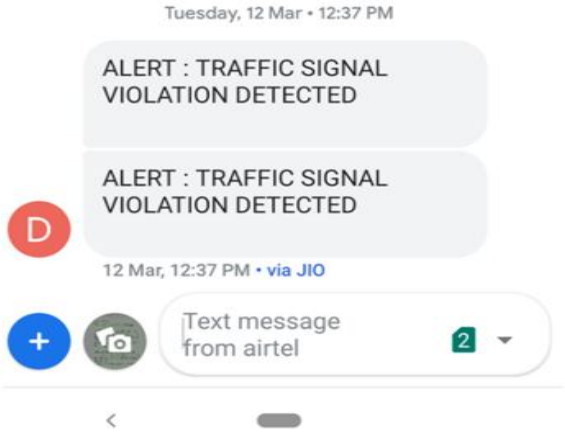

Figure 5. SMS Alert

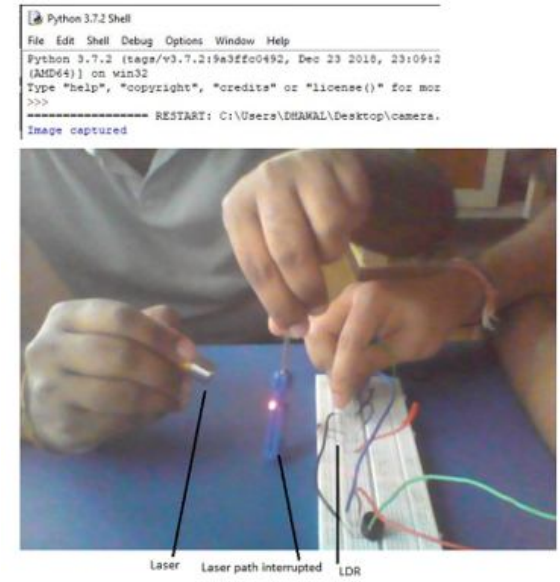

Figure 6. Image captured by camera during violation.

5. CONCLUSION

Although the circuit charges the battery connected to it, which is not connected to the main system. This circuit can be integrated with the main circuit with the help of appropriate battery management system. The image of the vehicle is captured while it is violating the traffic signal. Different image processing techniques can be applied to the captured image and vital information (such as the vehicle number) can be extracted. Hence all the results which are required to be obtained from all the circuit are correctly obtained and verified. This system has the capability to be implemented practically for usage and thus real time problems can be solved from it. If all these factors are taken into consideration and implemented with the system than the overall system will give all the needed result with highest accuracy.

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