Intelligent Traffic Signal Management System Using Arm-7 Controller

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Abstract: **There has been a tremendous growth in the traffic due to urbanization, industrialization and increase in population. Recently conducted study on traffic management market reports that the traffic management market is expected to grow from $3564.9M in 2014 to $16894.9M by 2019. Hence it has become essential to build an intelligent traffic control and monitoring system in order to resolve the traffic congestion of roads and reduce accidents. This paper is designed to develop a density based dynamic intelligent traffic signal system having remote override facilities. The traffic signal duration changes automatically on sensing the traffic density at the junction and in the event of any emergency vehicle like ambulance, fire brigade etc. requiring priority are built in with RF transmitter and receiver. It overrides the traffic signals by providing instantaneous green signal in the desired direction while blocking the other lanes by red signal for some time.**

Keywords: **LDR: Light Dependent Resistor, LED: Light Emitting Diode, Rx: receiver, Tx: transmitter, RF: Radio Frequency, LPC: Low Pin Count**

I. INTRODUCTION

Although traffic signals play an important role in safe operation of roadways, they can be a source of inefficiency leading to wastage of time, excessive consumption of fuel *etc*. The delay interval of each light is hard coded in the conventional signal systems and is not dependent on density of traffic. The density based traffic signal system [1] strives to reduce the traffic congestion by considering the density of traffic on each lane. The time interval of green and red light changes dynamically based on density of traffic on each lane.

Moreover, in the case of conventional traffic signal system, an emergency vehicle like ambulance, police car, fire brigade etc., is not prioritized which can lead to catastrophic disaster. To resolve this problem, an emergency override along with the density based signal system can be incorporated. In this case if an emergency vehicle needs to be prioritized, the driver can use the override system.

The main objectives of Intelligent traffic signal management system [2] is to avoid and reduce wastage of the time at the traffic junctions caused due to fixed time interval signals by making a density based traffic signal system, monitoring the traffic efficiently in night time, providing priority to the ambulance, fire engines and other emergency vehicles at the traffic junction.

II. FUNDAMENTAL CONCEPTS

IR Sensors: These are the sensors which detect IR rays. These are incorporated to detect the presence of vehicle by detecting reflected IR rays [3]. The IC LM358n is the IR sensor used. This sensor consists of two part one for transmitting the IR rays and the second to receive the IR rays.

The transmitter is always on and continuously emits the IR rays. Whenever the vehicle passes in front of the transmitter the rays gets reflected and are received by the receiver which is tuned for a particular distance using a potentiometer. The output of the IC LM358n is given to the ARM 7 controller which will manage the traffic lights accordingly.

*RF RX/TX***:** They are used to provide highest priority to the emergency vehicle. They will communicate with a frequency of 433MHz.The RF transmitter is incorporated in the emergency vehicle and is active all the time. The receiver which is connected to the ARM 7 controller will sense the presence of emergency vehicle within a 100 meter range from the traffic junction. HT12E is used as a transmitter. This will generate the signal, encode the signal which is followed by amplitude shift key modulation. The modulated signal is then amplified and sent in all direction using an antenna. After capturing the transmitted signal the receiver HT12D will demodulate the signal and decode it to the original signal.

LDR: These are light dependent resistors. Their resistance value varies from 100 Ω to few Mega Ω. When there is no incident of light the electron are bound to the atom in LDR. Once the intensity on the LDR starts increasing, energy is given to the atoms of LDR which will take the atoms to the excited state and hence releasing free electrons resulting in low resistance.

*ARM 7 Controller***:** ARM 7 controller is 32 bit microcontroller. It has 8KB to 40KB of on chip RAM and 512KB of flash memory and the written code is dumped. Large code can also be dumped. It works in an operating temperature of 40 °C to +85 °C [5]. Therefore it can be used in a real time environment. It handles the external interrupts by categorizing into Fast Interrupt Request, Vectored Interrupt Request and Non-vectored Interrupt Request. It has totally 64 pins out of which 45 pins can be used as general I/O pins,

hence can be used for future enhancement of the implemented work.

III. METHEDOLOGY

Figure1 shows the functional block diagram of the Intelligent Traffic Signal Management System. The implemented work consists of ARM7 Controller, Comparator, LED Drivers, IR transceivers, LED's, Switch and LDR. It uses 8 IR sensors which are divided into two groups, with 4 IR sensors in each group [6]. At the traffic junction, two circles named as inner circle and outer circle are created. Each road consists of one inner circle IR sensor and an outer circle IR Sensor, 3 LED'S (Red, Green and Yellow) and 2 LED'S (Red and Green) for the pedestrian zebra crossing.

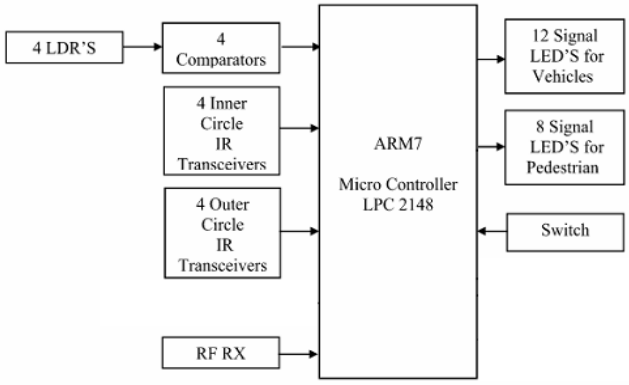

Figure1 Functional diagram of intelligent traffic management system

A step-down transformer is used in the circuit for standard power supply that converts from 230V to 12V. There are 4 diodes that forms a bridge rectifier that delivers pulsating DC, an electrolytic capacitor of 470pF is used for filtering.

The filtered DC is unregulated hence IC LM7805 is used to get 5V DC constant. The regulated 5V DC is further filtered by a small electrolytic capacitor of 10uF for any noise generated by the circuit. ARM 7 Microcontroller is the brain of this whole implementation and is used to initiate the traffic signal at the intersections of the road. [7] The LED's get automatically switched on and off by making the corresponding port pins of the microcontroller high, based on the ARM 7 microcontroller. ARM7 is programmed using KEIL software.

Day mode: A minimal time interval of 30 second is allotted for each road. After completion of one round (All four road Signal) the Controller checks the outer circle sensor (Density Sensor) and depending on the traffic congestion, that particular road will be released [8]. When the green signal is activated for a particular road, the inner circle sensor will monitor the traffic. If no vehicle is detected on that road for 10 seconds, it will automatically turn the green signal to red and switches to the next road.

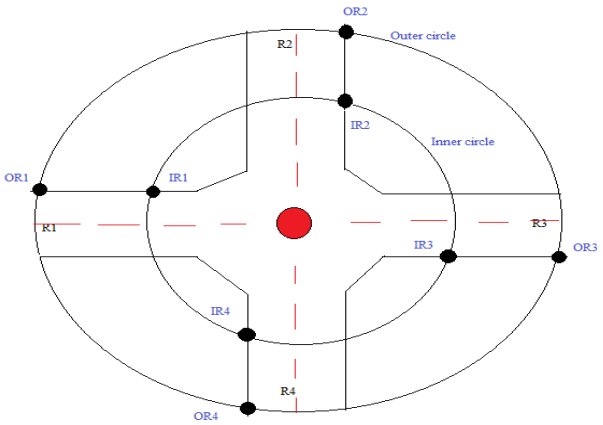

Figure 1 Division of traffic junction

Figure 2 shows the division of traffic junction. The traffic junction is divided into two circles i.e inner circle and outer circle. Each road contains one inner IR sensor, one outer IR sensor, one LDR.

Night mode: During the night time this intelligent traffic signal system works with the help of LDRs (light dependent resistors). LDRs fitted at each road senses the head light intensity of the vehicle which is coming towards the junction and with the help of comparator it detects vehicles allotting signals for the roads accordingly. A manual switch is used to convert the system to night mode.

IV. SYSTEM ARCHIRECTURE

ARM 7 controller has two ports each containing 32 I/O pins. These I/O pins are used to interface the external devices. Before mounting these pins are tested.

PORT 0

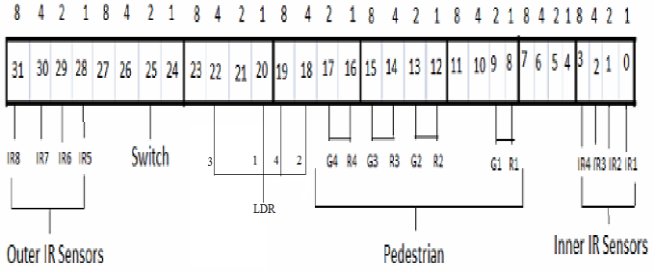

Figure 3 PORT0 of ARM7

Figure 3 shows the PORT0 of ARM7 controller. First nibble of PORT0 is used for connecting inner IR sensors. Outer IR sensor is connected to last nibble of PORT0. Rest of the pins are used to connect pedestrian signals, switches and LDR.

PORT 1

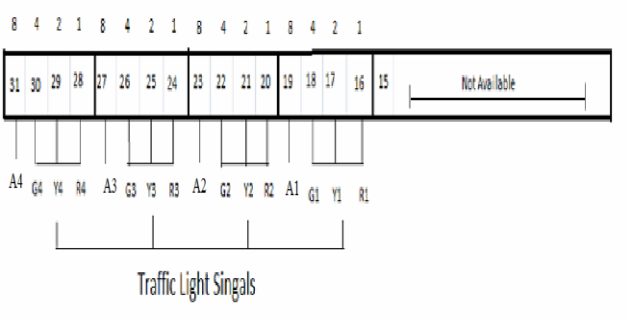

Figure 4 PORT1 of ARM-7

Figure4 shows the PORT1 of ARM7 controller. In port1 the first 4 nibbles are not available for usage. The traffic lights (LEDs) and the emergency vehicle RF receiver is connected to ARM in port1.

V. IMPLEMENTATION

Power Supply: Each component of the system works only when they are given with sufficient energy. It is provided with a help of power supply unit. This unit will convert the 230V AC current to 5V DC current. All the components work with direct current. Hence 5V DC current is given to each of the component. The adaptor used will house the power supply unit. Circuit diagram of power supply is shown in the Figure 5.

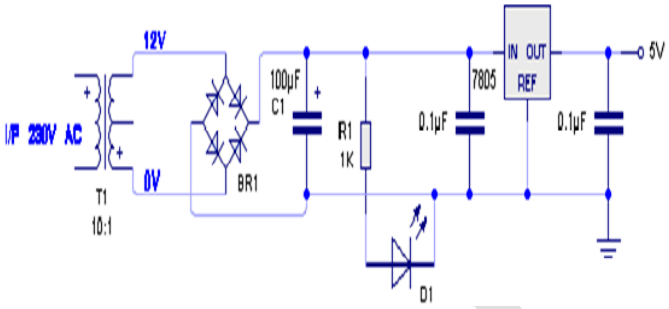

Figure 5 Power Supply Unit

The main building block of any electronic system is the power supply, to provide sufficient energy for their operation. For ARM 7 controller, amplifier, keyboard, edge connector +5V is required. To run the motor +12V is required. Regulated output voltage of +5V, and non regulated output voltage +12V is provided by the power supply. Three terminal IC 7805 meets the requirement of +5V regulated.

IR Sensor Circuit Diagram: As the name indicates these are the sensors which detect IR rays. These are incorporated in the system to detect the presence of vehicle by detecting reflected IR rays. [9] The IC LM358n is the IR sensor used in the system. This sensor consists of two part one for transmitting the IR rays and the second to receive the IR rays. Figure 6 shows the circuit diagram of IR Transmitter and figure 7 shows the circuit diagram of IR Receiver.

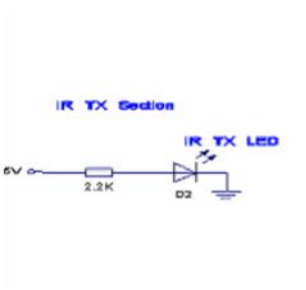

Figure 6 IR Transmitter

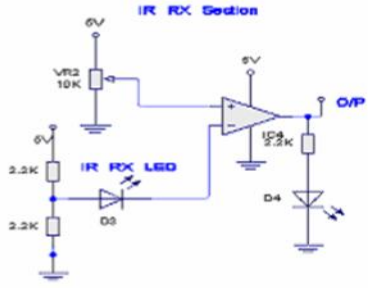

Figure 7 IR Receiver

RF Transmitter: The transmitter will generate the signal which is then encoded with the help of an encoder. This is done to increase the security. Since RF signal moves in every direction they need to be supported so that the loss of energy is reduced. The modulator is used to bind the RF signal with the carrier signal [10]. Once the signal is bounded with a carrier signal it is then amplified and transmitted through the antenna.

This operation is showed in Figure 8. The signal travels in all direction and then will be caught by the receiver with the same crystal frequency. In this system, the matching crystal frequency of 433MHz is used. When the signal is transmitted bythe RF TX of 433MHz it is caught by the receiver of 433MHz [44][45]. Hence security is improved.

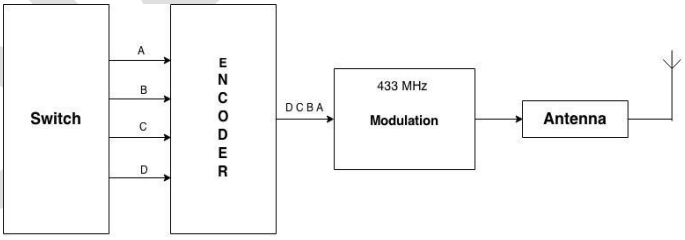

Fig 8. RF Transmitter

RF Receiver: The RF receiver will perform the reverse operation as of RF transmitter. First the receiver will capture the signal of matching crystal frequency. It is then amplified since the signal loses energy due to interference. This amplified signal is demodulated to remove the carrier signal. Here also once again amplitude shift key is used [11]. Once the original signal is regained, it is processed through decoder which decodes the fragments from the signal. This signal is given as the input to the ARM 7 controller. The operation of RF Receiver is shown in the Figure 9.

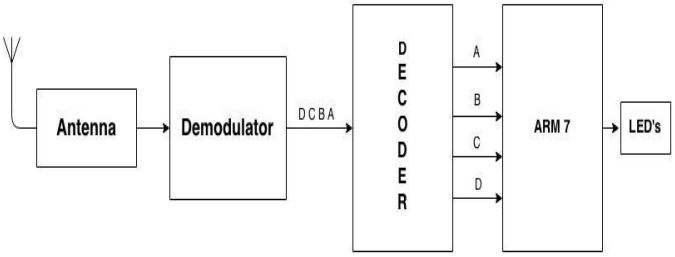

Figure 9. RF Receiver

Comparator: The comparator is used to compare the voltage level with the reference voltage. The output of the comparator will be 1 if the input voltage is equal/more than the reference voltage otherwise it will be zero [12]. The circuit diagram is shown in Figure 10 which indicates that the comparator used houses LM324 IC which is quad OP-AMP.

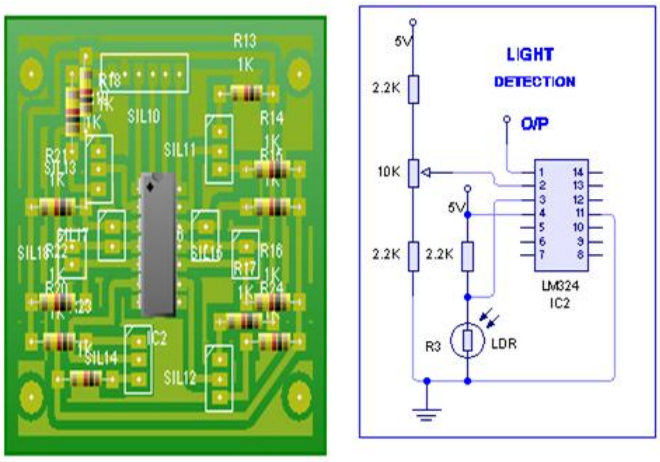

Figure 10 LDR Circuit

- As shown in the Figure 10 is the comparator of a 14 pin IC
- Pin number 1, 7, 8, 14 are the output that are connected to the ARM controller.
- Pin number 2, 6, 9, 13 are the reference point
- Pin number 3, 5, 10, 12 are the points where LDRs are connected.
- It has a bandwidth gain of 1.3MHz
- It works at an operating temperature of +3V to +30V.
- That light is focused on LDR and the voltage cross the output is read with the help of multi meter. And then the preset is tuned to half of the voltage.

VI. PLATFORM

Embedded C: Embedded C is the language for the micro-controller. With other languages it is very difficult to interact with the hardware devices in a real-time environment [13]. So a special language is developed which uses C construct along with hardware interfacing structures and instructions. With the C language it is easy to develop the program. Since C is the base for many of the languages, it is very familiar and easy to write. The interfacing of hardware is done through very easy and simple constructs of embedded C language. These advantages are leveraged

*Keil Micro Vision (IDE***:** The µVision IDE from Keil combines project management, make facilities, source code editing, program debugging, and complete simulation in one powerful environment. The µVision development platform is easy-to-use and helps to quickly create embedded programs that work. The µVision editor and debugger are integrated in a single application that provides a seamless embedded project development environment.

LPC Flash Utility: LPC Flash Utility is used to dump the written code onto the 512KB flash memory of ARM 7 controller. It is an In System Programming (ISP) tool for NXP microcontroller like ARM 7 controller. It is used to communicate with the test board. The address of the hex file which needs to be dumped onto the flash memory of ARM 7 controller is given in the file box. The crystal frequency of the test board is written in the frequency box. In this system the frequency of the test board is 12000 KHz. Once the hex file is dumped and the new dumped program is executed.

VII. PERFORMANCE EVALUATION

Performance evaluation criteria used are number of vehicles waiting at the junction, operation during emergency mode and green signal timings. The performance is evaluated with the conventional fixed time traffic light controller and checked against the proposed intelligent system.

- *Number of vehicles waiting at the junction:*

Evaluation is done considering 3 minutes of time. Number of vehicles waiting at the junction is calculated at the end of 3 minutes. In the conventional method signals are released after every minute. The performance is separately calculated for Fixed Time Mode and Intelligent Traffic Signal management system.

The results of this experiment are shown in Figure 11. The figure indicates that the total no of vehicles waiting at the junction in Intelligent Traffic signal system is lesser than the conventional method. The Intelligent traffic signal system takes into account the physical presence of vehicles for deciding signal timings. This indicates the proposed model saves time to a large extent.

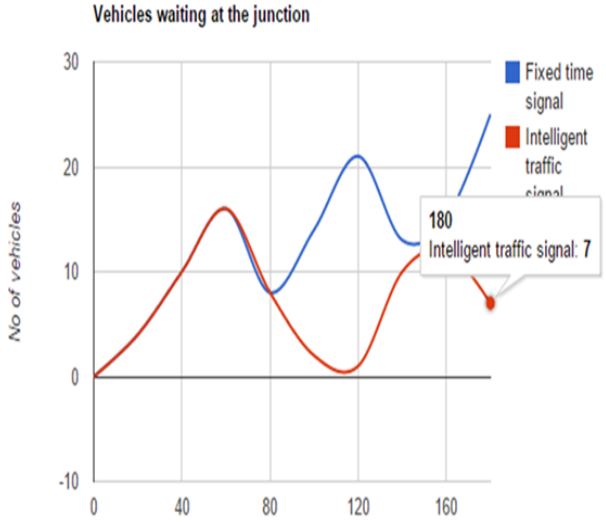

Figure 11. Performance Evaluation showing number of vehicles waiting at the junction after 3 minutes

- *Operation during emergency mode:*

In case of arrival of Emergency vehicles like Ambulance, Fire Bridge, Police Vehicle, emergency mode is activated.

It is observed that this mode of operation works properly by providing green signal for the particular road when there is an emergency vehicle.

- *Green signal timings:*

Conventional method of traffic signal does not depend on density of traffic at the junction. The implemented work changes signal timings according to the vehicle densities. Green signal timing is plotted against traffic density and performance is analysed. Figure12 shows that as the density of traffic increases green signal timings also increases accordingly till the threshold value of 30 sec.

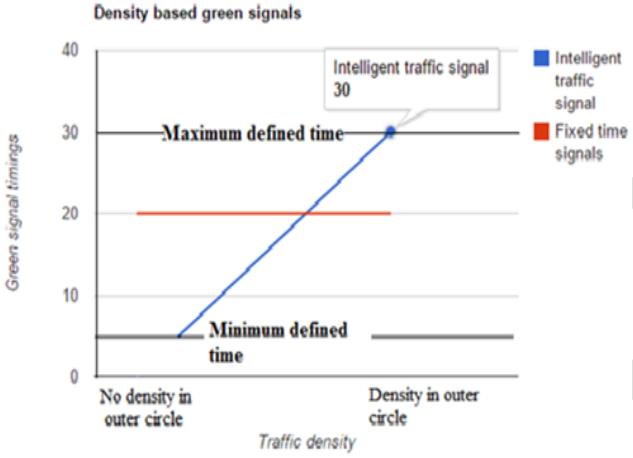

Figure 12. Performance Evaluation based on green signal timings

VIII. CONCLUSION

This system helps to avoid the wastage of time at the traffic junctions. It also has the potential to revolutionize traffic surveillance and control technology because of its low cost and the capability for large scale deployment. The optimization of traffic light system is achieved in this system by using IR sensors, LDRs and ARM 7 controller. The implemented system has the potential to reduce the possibility of traffic jams which might occur due to long delays hard coded in the conventional traffic light systems.

The ITS system developed calculates the density of vehicles on the road for the flow of the traffic smoothly without congestion The priority based signalling giving priority to the emergency vehicles are implemented successfully. It was observed that the total waiting time of vehicles at the intersections can be reduced up to 61.54%. Thus, this traffic signal management approach when properly operated and maintained yields significant benefits like less congestion of traffic at the junction, saving fuel consumption and effectively handling the traffic during the night time with the help of LDRs rather than using blinking yellow light concept.

IX. FUTURE WORK

The future work of gain system includes updating the traffic information to the people by using Internet of Things and WSN. It is also possible to develop a cost effective system which is weather resistant and has the potential for more sophisticated applications, including vehicle speed measurement and length classification. Accident detection and rescue can also be implemented in this system using GSM and GPS modules, and pressure sensing devices which, on any unfortunate event of accidents, informs the nearest hospital about it.

Accidents at the traffic junction can be located with a GPS module and messages to the nearest ambulance can be sent with the help of GSM module.With the help of video transmission and processing the traffic violation can be controlled. Using Internet and navigation the Ambulance can be directed with a alternative route if there is a heavy traffic jam at the junction.

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