Design of Intelligent Traffic Light Controller Using FPGA

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Abstract— **The design and implementation of a real-time traffic light control system based on Field- programmable Gate Array (FPGA) technology is reported. The traffic light control system is designed with VHDL language. Its function will be verified with simulation. After that, the VHDL design will be downloaded to FPGA board hardware to verifying its function in paper. The designed traffic light control system is shown to work properly as expected. This design uses the VHDL hardware language description by text. In the establishment of the general expectation function, it uses the hierarchical design to realize alternating lit the traffic lights, the countdown time display and vehicles' and pedestrians' safe passing command. The program's data can be set base on actual conditions (flexible modification). Our paper aims to eliminate the delay on roads by reducing traffic on road automatically using FPGA. It determines traffic on each road by using sensors. Using that traffic information we can manage the signal time and handle the traffic on road. On each road we place IR sensors which detect the vehicle and give current traffic information on each road.**

Key words*: *ITLCS, Sensor, Traffic Congestion, FPGA System, VHDL

I. INTRODUCTION

Traffic research has the goal to optimize traffic flow of vehicles. As the number of road users constantly increases, and resources provided by current infrastructures are limited, intelligent control of traffic will become a very important issue in the future. However, some limitations to the usage of intelligent traffic control exist. Avoiding traffic jams for example is thought to be beneficial to both environment and economy, but improved traffic-flow may also lead to an increase in demand.

The traffic congestion due to the exploding increase of vehicles became the severest social problems and it has a major effect on the economy of a country. Therefore, many researches about traffic light system have been done in order to overcome some complicated traffic phenomenon but existent research had been limited about present traffic system in well-travelled traffic scenarios. There are several models for traffic simulation. In our research we focus on optimization of traffic light controller in a city using IR sensor and Traffic light controller system using FPGA.

Field Programmable Gate Arrays (FPGAs) are extensively used in rapid prototyping and verification of a conceptual design and also used in electronic systems when the mask-production of a custom IC becomes prohibitively expensive due to the small quantity. Many system designs that used to be built in custom silicon VLSI are now implemented in Field Programmable Gate Arrays. This is because of the high cost of building a mask production of a custom VLSI especially for small quantity [2]. Through using VHDL language to the traffic light controller design, the traffic light control circuit uses digital signal automatic control to realize two groups of lights which are red, yellow and green[9][12]. Those lights command vehicles and pedestrians passing safely at the crossroad, which bases on the data of traffic state transition [1]. There are two kinds of the VHDL design, which are modeling and synthesis. The modeling VHDL design has significant advantage in complicated system design. In addition, the VHDL should not be thought as a programming language. This language is designed to describe the logic circuit. A classic model is a very helpful point to start programming the project. [3]

The FPGA traffic light control system needs to consider the current traffic situation, which is base on the data from sensors. The FPGA gets current signals of vehicles passing crossroad and base on those signals send next step order. Also, in the specific road the traffic light should be set specifically [2]. In addition, the FPGA need to consider the time, which means separating the traffic situation by the time [4].

The rest of this paper is organized as follows: section 2 reviews the literature review. In section 3, we introduce the details of the proposed scheme. Section 4 we discusses implementation details and presents the simulation results. Section 5 concludes the paper. At the end of the paper is a list of references.

II. LITERATURE REVIEW

Farheena Shaikh, Dr. Prof. M. B. Chandak [1] describes an approach towards Traffic Management System using density calculation and emergency vehicle alert. In this paper, Wireless Sensor Networks deployed along a road can be utilized to control the traffic load on roads and at traffic intersections. Sensors are deployed on either side of roads at intersection points and in emergency vehicles respectively. These sensors run on both solar energy as well as battery. Existing traffic light systems have timers that are set at regular intervals. This leads to the wastage of precious time especially in case of rescue vehicles for emergency conditions. In order to control this situation, they have proposed a system consisting of two parts: Smart Traffic Light Control System (STLC) and Smart Congestion Avoidance System (SCA) during emergencies. STLC System controls the change of traffic lights at intersection points giving high priority to emergency vehicles. SCA System is a smart traffic routing system that chooses the shortest routes having the least congestions. The system based on GPS so it has some drawbacks in implementation. Thus this system is somewhat unreliable.

AT&T [2] experimented with the use of applied acoustic and digital signal processing technology to produce a vehicular traffic surveillance system (Nordwall, 1994). Labeled the SmartSonic Traffic Surveillance System (SmartSonic TSS-1), the project was intended by AT&T to replace buried magnetic loop9 detection systems. This technology was originally developed from research used by the U.S. Navy for

submarine detection purposes. Mounted above passing vehicles, the SmartSonic [3] TSS-1 listens to the acoustic signals of vehicles and is capable of distinguishing between larger trucks or buses and smaller vehicles. Applications were to include traffic monitoring and vehicle counting, with the potential for incident detection being an area for further research. In their discussion of video-based surveillance, Berka and Lall continue the discussion of improving upon the use of loop detection to gather traffic data (1998). The authors claim that loop detection reliability is low, and that maintenance and repair of such a pavement-based system creates safety risks for repair crews. Berka and Lall maintain that non-intrusive technologies such as video surveillance provide reduced traffic disruption during installation or repair. In addition, video surveillance is capable of detecting incidents on the sides of roadways, outside of the detection range of loop detectors.

N. M. Z. Hashim, A. S. Jaafar, N. A. Ali, L. Salahuddin, N. R. Mohamad, M. A. Ibrahim deals about Traffic Light Control System for Emergency Vehicles Using Radio Frequency. According to all these papers, a convenient wireless communication between emergency vehicles and the traffic light is by using RF. The prototype of this project is using the radio frequency of 434 MHz compared to the range of about 3 kHz to 300 GHz of frequency which have been reserved for the RF theoretically. There are three objectives to be achieved in this project. First is to analyze and implement wireless communication; Radio Frequency (RF) transmission system in traffic light control system for emergency vehicles. Second is to design a traffic light sequence for emergency mode when receive signal from emergency vehicles. Last objective is to change the sequence back to the normal sequence before the emergency mode was triggered. This project has contributed in implementing the wireless communication by using the radio frequency (RF) transmission of 434 MHZ in the traffic light control system for emergency vehicles. This system was designed to be operated when it received signal from emergency vehicles based on radio frequency (RF) transmission and used the Programmable Integrated Circuit (PIC) 16F877A microcontroller to change the sequence back to the normal sequence before the emergency mode was triggered. This system will reduce accidents which often happen at the traffic light intersections because of other vehicle had to huddle for given a special route to emergency vehicle.

Ms Promila Sinhmar in Intelligent traffic light and density control using IR sensors and Microcontroller (IJATER) describes the optimization of traffic light controller in a City us- ing microcontroller. The system tries to reduce possibilities of traffic jams, caused by traffic lights, to an extent. The system is based on microcontroller. The micro- controller used in the system is 89V51RD2 which is MCS- 51 family based. The system contains IR transmitter and IR receiver which are mounted on the either sides of roads respectively.

The IR system gets activated whenever any vehicle passes on road between IR transmitter and IR receiver. Microcontroller controls the IR system and counts number of vehicles passing on road. Microcontroller also store vehicles count in its memory. Based on different vehicles count, the microcontroller takes decision and updates the traffic light delays as a result. The traffic light is situated at a certain distance from the IR system. Thus based on vehicle count, microcontroller defines different ranges for traffic light delays and updates those accordingly. But Microcontroller has many disadvantages compared to FPGA. In case of the speed, number of input/output ports and performance which are all very important in TLC design, FPGA is more advantageous than Microcontroller.

Hao Dong, Xingguo Xiong and Xuan Zhang in ASEE 2014 Zone I Conference, April 3-5, 2014, University of Bridgeport describes Traffic Light System based on FPGA. The FPGA traffic light control system needs to consider the current traffic situation, which is base on the data from sensors. The FPGA gets current signals of vehicles passing crossroad and base on those signals send next step order. Also, in the specific road the traffic light should be set specifically. In addition, the FPGA need to consider the time, which means separating the traffic situation by the time. In the FPGA programming the codes should be packaged base on different models, which could increase the programs' flexibly. The states machine is good way to separate the system to different function model. But this method gives only simulation results.

A) Advantages of fpga over microcontroller

- FPGAs are going to rule in the future because of their flexibility, increasingly better power efficiency and decreasing prices.
- FPGAs are flexible, you can add/ subtract functionality as required. This cannot be done in microcontroller.
- FPGAs are favorite in military applications. There are two main reasons of that. The first thing is that FPGAs are hard wired and the random attack of α- rays cannot destroy the memory areas hence collapse the device functionality.
- The second reason is that the lifetime of FPGA based development is longer. It can be adopted for advanced chip.
- Microcontroller change too often and there is lot of rework required to do in order to keep pace with changing technology. This is necessary to save the design from being obsolete.
- The flexibility of FPGAs gives them distinct advantage over other programmable logic devices.
- FPGAs are reprogrammable and can implement any sort of logic circuits, designs can be modified after initial implementation.

III. PROPOSED TRAFFIC LIGHT CONTROL SYSTEM

In the Traffic Lights design, the external hardware includes four sets of traffic lights and four LED displays. The software system bases on

(a) Circuit synthesis module concept: the traffic signal system is divided into several small circuits. Each module is written in VHDL codes. Those small circuits also connect together. This subdivided working design increases the speed of debugging and programming.

(b) Parameterization concept: the traffic light circuit can be adjusted by the time (increase or decrease the count time in circuit) to increase the flexibility of process.

At the traffic lights signal system, it is most likely to use the automatic control mode. In order to avoid the occurrence of accidents the circuit must be given a stable clock to make system working normally. The special point during the design process is using constant parameter. The intention of using constant parameter is in order to make the program easier to read and modify. Changing the values of the constants updates constant's value for whole program, which enhance the flexibility of this project. In addition, at the programming process all of the constant parameters inputs and outputs are given some evident names. It increases efficiency of debugging and makes the project easy to be fixed by another programmer, because the function of every part is obvious. (i)

The program defines the normal traffic. Under this condition, the maintain time of red light vector, yellow light vector and the green light vector are 15s, 5s and 25s on both meridional and transmeridional direction. Base on the real life experience, some traffic light already use the countdown (ii) display. Their role is telling the vehicles and pedestrians how much time they have by the traffic signal changing. So, the vehicles and pedestrians know whether there is enough time to pass the intersection, which can avoid some accidents.

Fig. shows the schematic diagram of traffic light controller. The traffic light system is mounted on four road gridlock. The system consists of sensors, set of traffic lights. Two sensors are placed on each road. The sensors are placed apart from each other at some distance. Proper distance is maintained between two sensors. The IR transmitter is connected to the power supply. When the system is started the sensors i.e IR transmitter detects the traffic and gives the traffic information to IR receiver. It transmit continuously high voltage (1). If the obstacle comes in front of IR transmitter , the IR receiver senses the low voltage (0). Depending upon the receiver output the traffic light signals works i.e. ON time may vary. The variation in ON time of traffic signal depending upon the amount of traffic present on the road.

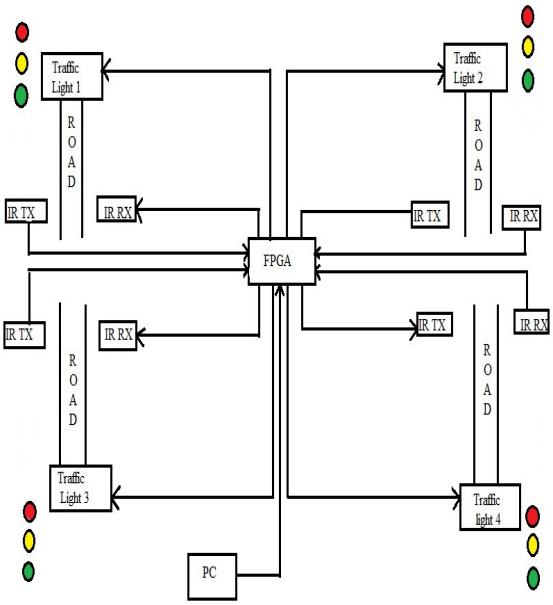

Fig:1. Block Diagram of System Design

The IR receiver is connected to FPGA kit. The FPGA kit works according to the IR receiver output. The output of FPGA is given to the traffic light sets. According to the amount of traffic present on the road FPGA assigns the particular time to the traffic light on each road. As the two sensors are mounted on each road it is easy to find the length of traffic present on each road. The length of queue helps in determining amount of traffic on road.

The on-off time of traffic light varies depending upon the amount of traffic present on each road. This reduces the unnecessary waiting time for drivers.

System operation flow chart:

According to the chart, firstly the system is started. After initialization the system checks the clock and clock' event. If clock and clock'event =1 then it checks next condition of standby otherwise it again checks the clock and clock' event. For proper operation of system it will remain '1'.

(ii) After checking the clock condition the system checks whether the standby is 1or not. If it is '1' then the Yellow light should glow (ON) and the Red and Green lights remain OFF. Whenever standby signal indicating '0' that means there is no standby condition and system checks next condition of sensors which are placed at a distance from each other.

(iii)The sensors placed on both side of the road detects the traffic on the road. Depending upon the sensor output the particular light will turn ON. When the sensor output is '11' then the Red light will turn ON and remaining Yellow and Green light should remain OFF. If the sensor output is not '11' then it checks for next condition and reacts accordingly.

(iv) The sensor senses the traffic and its output is '10', then the Green light should be ON and remaining Yellow and Red light will remain OFF. The Green light will remain ON for particular amount of time. The different ON time are assigned to every traffic light depending upon the traffic on the road.

(v) If the sensor output is not '10' then the system checks for next condition. If the sensor senses '01' that means there is more traffic on the road. After detecting the amount of traffic FPGA assign fixed time to the GREEN light to remain ON. The GREEN light should remain ON for 25 sec. The other two lights i.e YELLOW and RED remains OFF.

(vi) If the IR receiver has '00' at its output then it indicates that the road is more crowded. Therefore more time is required to pass the traffic. Thus, in this case, the ON time of GREEN light will be more. This is done to reduce the traffic congestion and traffic jams. The other two light YELLOW and RED light will remain OFF.

(vii) If the sensors output is ZZ then the three lights i.e. GREEN, YELLOW and RED reacts depending upon the output. At the time of checking the sensor output if the condition is true then the traffic light should remain ON for fixed time and again repeats the procedure from beginning.

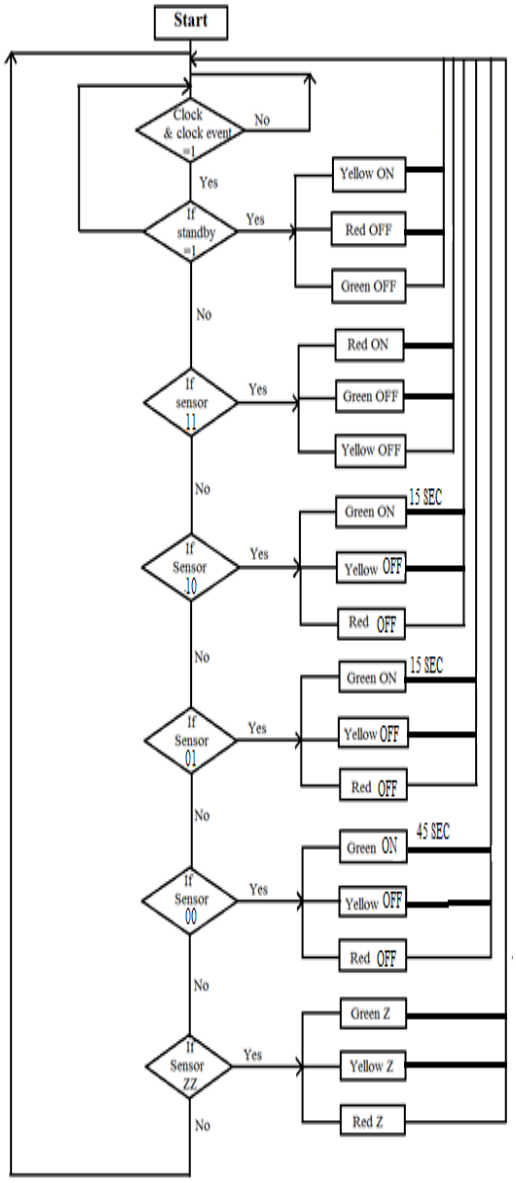

Fig:2. Flow chart of operation

IV. IMPLEMENTATION DETAILS AND SIMULATION RESULTS

The hardware system was developed by using IR sensors and LEDs. The LED denotes the Traffic light sets on each road. IR sensors are placed on placed on road. It is used for vehicle (obstacle) detection. The simulation results and hardware model is as shown below,

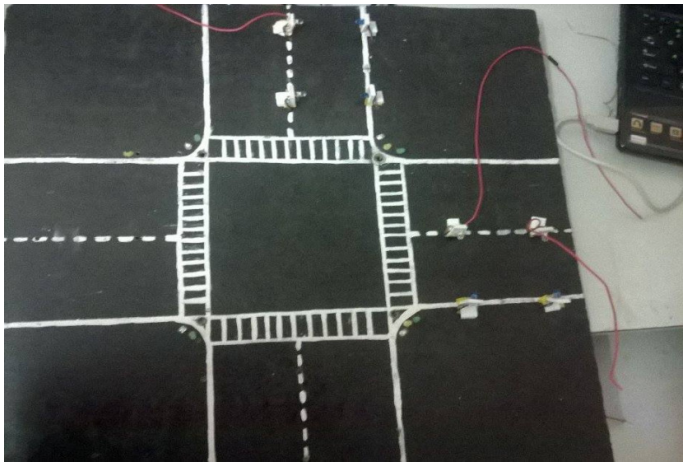

Fig:3.Hardware model

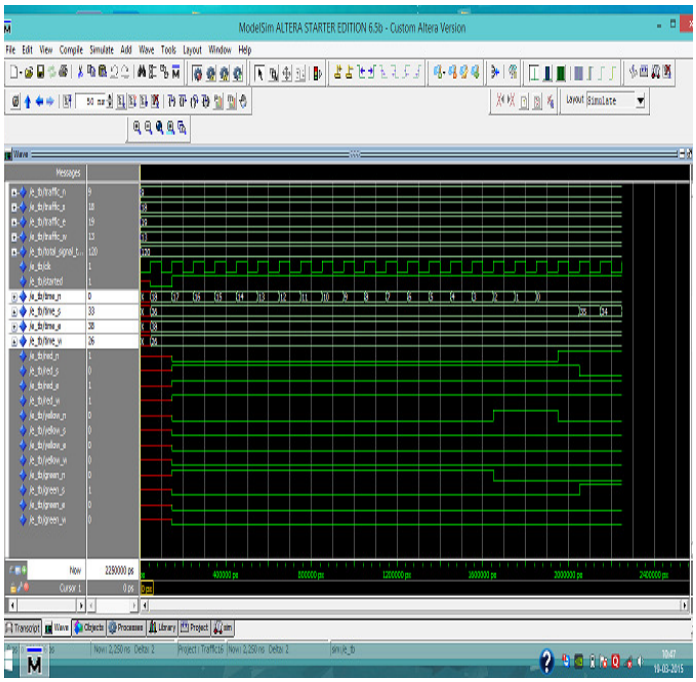

Fig:4.Simulation results

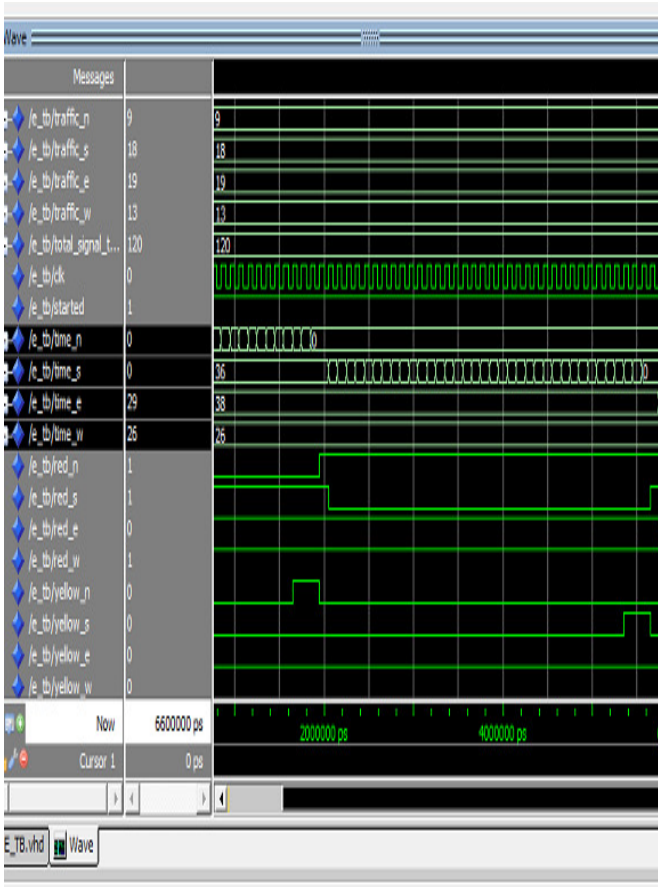

Fig:5.Simulation results

V. CONCLUSION & FUTURE SCOPE

Here we have implemented our proposed scheme for the purpose of controlling and handling of variety of timing tasks implementing all the features of an FPGA into the system making the system robust, precise and accurate. Here we have made Intelligent Traffic Light Controller Using FPGA as a part of our work.

In future this systems can be used to inform people about different places traffic condition data transfer between FPGA and computer can also be done through telephone network , data call activated SIM These technique allows the operator to gather the recorded data from a far end to his home system without going there as we can run many applications on single FPGA kit. Traffic lights can be increased to N number and traffic light control can be done for whole city by sitting on a single place or automatically.

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