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Advanced Traffic Light ControllerSystem Using FPGA Implementation

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Abstract: ***The people's population, and the vehicles which travels on the roads are increasing in our day today life, the traffic congestion is the major problem in major cities. The major reasons behind the traffic issue is that the inefficiency of the techniques and algorithms which are used in the existing traffic light system which are unable to adapt to the continuous traffic situation and eventually lead to traffic congestion. Therefore, to prevent these situations we introduces an advance system which are able to improve the current traffic control. In this project, an FPGA based Smart Traffic Light Control System (STLCS) is proposed with number of vehicles which are further used to calculate the proper time for control of signal lights by using the timing algorithms. Once the timer limit is reached, then the other light turns ON and the request signal is fed to the FPGA, to calculate the signal for the next turn, these processes are done repeatedly. Moreover, a precautionary measure has a maximum and minimum green light timer which are fixed within the timing algorithm to prevent the vehicle detection error, and the waiting of vehicles in queue in other lanes. In this project,*** I_{Sim} ***software are used to simulate the traffic light controller system that are written in Verilog Hardware Description Language (HDL).***

Keywords: Traffic Congestion, FPGA, Verilog, Isim , HDL, Timing Algorithms.

I. INTRODUCTION

The Traffic congestion is the major issues in the world. The Traffic congestion may cause many critical problems and challenges. Due to these congestion, people lose time, miss their opportunities, and get frustrated. To solve these congestion problems, we have to build new facilities & the infrastructure to make it smartest one. The only disadvantage of making new roads which makes our surroundings more congested. Therefore many countries are working to manage their existing transportation systems to improve their mobility, safety and traffic flows in order to reduce the demand of vehicle use. Therefore, many researches about traffic light system which has been done in order to overcome some complicated traffic phenomenon, but existent research had been limited due to the t present traffic system Field Programmable Gate Arrays (FPGA) are extensively used for rapid prototyping and verification of a conceptual design where the mask-production of a custom IC, which has becomes expensive due to the small quantity.

Traffic congestion occurs when the available street capacity is not able to accommodate, then the traffic demand and the several factors which cause traffic congestion, such as high rate of urban population growth, rapid increase in the number of automobiles, ineffective road construction strategies and management by government, and especially those non-adaptive traffic light system which is becoming obsolete andunable to handle high traffic density nowadays.

In order to overcome the impacts from traffic congestion, the invention of the Smart Traffic Light Controller System (STLCS) is vital to provide smooth motion of vehicles in the transportation routes and it alsoregulates the flow of vehicles through the traffic intersections of many roads. The conventional traffic light control systems react accordingly to the traffic density of the roads and it causes the major traffic issues due to the limited abilities which are not able to control the high traffic density.

II. LITERATURE REVIEW

Shyam Shankaran R et al.,[2021] has proposed about the traffic congestion which is the major issues in today's life. It cause critical problems and some consequences on the road. The pre-defined timer signal which leads to more on the road or at the intersections. The time-correlation is pre-calculated between the signal which is based on the traffic circumstance and it is analyzed at a particular junction. In a real time, it is not easy to except the system to cope up with the traffic conditions that may vary periodically from the existing timer. The fundamental concept behind the adaptive traffic control system is to construct a traffic management system to come across the existing traffic controller. The advance traffic controller helps to reduce the noise levels and pollution resulting in a lowfuel consumption. This system can be significantly enhanced with the introduction of techniques such as solar operated devices and sensor, with enhanced night vision capabilities[1].

Amaresh A M et al.,[2019] has proposed the traffic control in urban areas which is required to maintain an efficient traffic. The road accidents may causes to deaths and severe injuries. In earlier technology there are some flows to overcome from the density based traffic control system. The density based sensors are used to calculate the vehicles in latitudes and longitudes. The priority based scheduling algorithm is one of the basic idea to process the task according to the assigned priority and the algorithm is used to prioritize the traffic of each lane. (i.e.) Ambulance, when the priority is given to that particular lane it is clearing the allocation of traffic signals to be green, while the alternate routes are red.[2].

Simrit Kaur et al.,[2019] has proposed the number of vehicles in the metropolitan cities which has increased tremendously resulting in traffic congestion. The traffic control is a challenging task because it bring the difference between smooth flow and grid-lock of the traffic. This problem can be solved using the adaptive traffic light controller by implementing in FPGA system. This system senses the traffic, if any of the emergency vehicles are present on the particular road, it sense the vehicles and it gives priority to that particular road. Generally the traffic density is designed using Verilog HDL and it is implemented on Spartan3E FPGA. The design of adaptive traffic control system is easy to realize and which implements to provides the fastest response time ensuring the efficient of traffic management.[3]

Nouha Rida et al.,[2018] has proposed the congestion of road intersections which causes stress and tiredness for drivers. The current signal for controller assigns the duration for each light and the cycle is not adequate, when one lane has more vehicles waiting for the green signal, while other lane has less vehicles or no other vehicles waiting for the signal. The real time traffic changes at the intersection lanes results in order to improve the control efficiency of the traffic light, reducing the waiting time for the signals and avoiding the traffic congestion. The algorithm is used to reduce the waiting time of vehicle when compared to a fixed time control and this algorithm gives a priority for the small lane first and large lane based on the traffic at intersections. [4]. Xiao Wen-juan et al.,[2018] has proposed the rapid development to our society economy which has made the contradiction between the traffic lights and transport facilities. The intelligent transportation system was developed for the future in urban traffic management. Now a days camera is placed to analyze the real-time traffic at the intersection of the roads and it is used to calculate the dense of the traffic of each lane, which could provide a real-time data to the signals to control the dynamic signal configuration to achieve the traffic control system. This system can be used to provide the guidance for the system to provide the input data for grooming and control of traffic system. [5].

T.Bala Obula Reddy et al., [2017] has proposed the traffic control system which is the challenging problems in major cities. The poor traffic system is the main reason for an accident and time-loss. An advanced traffic lightcontroller can reduce the waiting time of the signal. First the density of the traffic is sensed throughout day and night. The advantage of this system is to sense the emergency vehicles and gives the priority to that particular lanewhich is sensed and this method also helps to find the defaulter who crosses the road during the signal. This method can be enhanced to control the signal automatically depending on the road side and it automatically turns off which helps in power consumption[6].

S. Venkata Kishore et al.,[2017] has proposed the traffic light controller which is used to control the congestion of vehicles and the pedestrian to cross the road safely. Many technologies are used for implementing a traffic light controller. This paper mainly works on design of FPGA traffic light controller at four junctions road with seven segment display at all directions for red, yellow and green lights. The future scope of this project can be directly used in real time applications [7].

Swapnil Manohar Shinde et al.,[2017] has proposedthe conventional traffic light controller which is based on the fixed interval of traffic lights. The most widely used traffic control system is fixed traffic light control system but it cannot meet the requirements of optimization on road. Due to non-adaptive nature the traffic congestion cause uneven flow on roadswhile adaptive traffic control system becomes the essential way of solving problems which are brought by fixed time control. Moreover this system is eco-friendly and has a simple architecture fast and reliable operation and with economically beneficial [8].

Amel Toroman et al.,[2017] has proposed the modern traffic flow which are unimaginable comprehensive use of computers and it describes the practical applications of PLC (Programmable Logic Controller) for controlling the real-time traffics An Intelligent Traffic Controller System is implemented and the results are obtained and the comparative analysis is preformed. In practical realization the use of PLC, has significant improvement which are made by the use of sensors [9]. Bilal Ghazal et al.,[2016] has proposed the traffic light controller system which are widely used to monitor and control the flow of vehicles through the junction of roads. The main aim is to realize themotion of the cars to be smooth in transportation to roads. The conventional system do not handle various flow which are approaching to the junctions. In addition the mutual interference between the adjacent traffic light system of cars, flow with time of accidents, the emergency passageof vehicles and pedestrian crossing are not implemented in the existing traffic system. Thisleads to traffic jams and the congestion at roads. In this proposed system PIC microcontroller evaluates the traffic density using IR sensor and accomplish the dynamic timing slots of different levels [10].

Shubhangi M. Deshmukh et al.,[2016] hasproposed the traffic congestion creates the negative impact on society and controlling of transportation is the most important thing in day to day life. The traffic management requires the technology based solution instead of manual methods such as human intervention via, traffic policemen, traffic lights and safety cameras. The traffic jamming can cause the commuter fails to reach the destination in time. Theproposed system smartly alerts the traffic congestion one the path one to travel. This system also helps us for the fuel level indication by GPS. The real time traffic congestion estimation is based on GPS communication. The existing system was used to detect the traffic congestion and their disadvantages. The system is enabled for road authorities to cover the whole road network withoutinfrastructure. The advantage of the driver, system tends to breakdown in long run and it is cost effective, smart, reliable and easy for maintenance [11].

Shashikant V. Lahade et al.,[2015] has proposed the economic development and progress of any country the roads plays an major role by providing the transportation ease for goods as well aspassengers. In traditional traffic light controller, thetime is fixed for the vehicles on each road to pass irrespective of the traffic intensity. This is an inefficient controlling method which consume time, effort and fuel of user unnecessarily also it doesn't have any provision of sensing and giving priority for the emergency vehicles to pass first. This problem can be addressed by Intelligent and Adaptive Traffic Light Controller(IA-TLC) implemented on FPGA using verilog as FSM with 35 states. In IA-TLC the density of traffic is sensed by using IR sensor throughout day and night accordingly time is allocated for user to pass. The traffic intensity is sensed accordingly the time is allocated for traffic to pass. The main feature of this system is the dynamic traffic pass time allocation and provision to detect the emergency vehicles like ambulance, fire brigade etc, giving them priority to pass first and then traffic resumes normally. The design of IA-TLC is easy to realize and implement on different FPGA boards which provides efficient traffic flow management [12].

Byeong-chan Jeon et al.[2015] has proposed the control system for solar powered LED traffic sign was designed. This system consist of 4 parts as energy transformation unit, energy charging unit, energy discharging unit and control unit. It has a various function such as day/ night transition, light-time control and battery protection. The road trafficsign recognition rate is very low at night than daytime because of low light intensity. The independent and the renewable power supply system for the traffic signal is needed. So the solar powered independent road traffic sign control system has emerged as the most realistic alternative. This method consist of solar energy transformation unit, storage unit and the controlunit for day/night transition and time setting. It is also expected to improve the solar road traffic system which will be used in the field [13].

Lala Bhaskar et al.,[2015] has proposed the use of inductive loops as an instrument to measure the traffic density the micro-controller can be programmed to receive the information from the traffic density on different lanes as measured by inductive loops. Depending on the traffic density a suitable algorithm can be executed to clear the congestion. In this proposed system model we make the use of radio transmitter-receiver to detect the presence of any emergency vehicles and provide the immediate right way by traffic signal. Many people who have a tendency of stopping beyond the zebra crossing at red signal. The determination of vehicle density using inductive loop promises an effective way of controlling the traffic system. A traffic density based microcontroller algorithm which takes into consideration of overall traffic condition of that junction and not just one lane at a time. The combination of all proposed system features offersa very efficient traffic management system [14].

Jatin Shridhar et al.,[2014] has proposed the design and simulation of power efficient traffic light controller (PTLC) focus on the simulation and optimization of PTLC design and computing its speed of operation. The design of PTLC is better than the conventional terms of LUT, complexity, size and cost. The proposed methodology of PTLC is represented with minimum number of LED which fairly improves the performance and makes the design efficient in terms of power and speed with respect to conventional designs. The PTLC has been implemented using FPGA .It has many advantages as number of speed, number of inputs or output ports and performance. The design of power efficient traffic light controller has been simulated and the output is verified [15].

Prashant Kumar Singh et al.,[2014] has proposed the traffic light system establishes a set of rules and instruction that drivers rely on the avert collisions and other difficulties using signs, lights and other devices. Now a days traffic light controller (TLC) is based on microcontroller and microprocessors. These TLC have limitations due to use of pre-defined hardware which functions according to the programs that has been done. Most of the TLC is implemented on FSM. The FPGA design implementation of 24 hours advanced traffic light controller system is based on congestion and road intersection using cortex M0. This system has been successfully tested and implemented in hardware using Xilinx Spartan 3E FPGA. The improvements of traffic control system is dependent on methodology used control system [16].

Meisam Ramzanzad et al.,[2013] has proposed to manage the traffic at the intersection the traffic light are often used. These lights are turned on and off at predetermined time. The intelligent traffic control system are designed to dynamically treat the problem of traffic and reduce the traffic, pollution and transit time of vehicles at intersection. In this paper the design of intelligent traffic

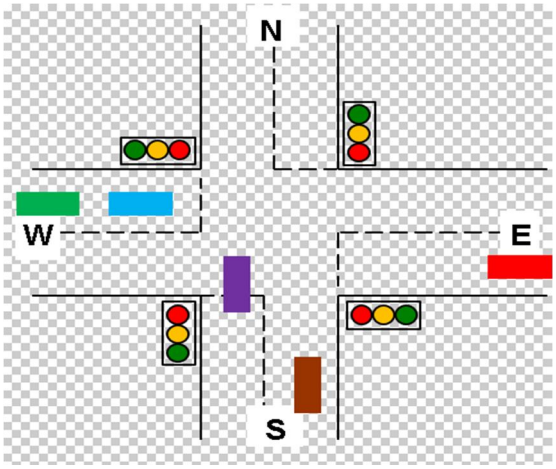
control based on fuzzy logic. The input parameters for intelligent controller are selected with various modes of intersections to be a true simulation of intersection environment. An important feature of intelligent traffic control system includes the speed and high precision, reducing traffic, air pollution and requires time to cross the intersections [17].

M.F.M.Sabri et al.,[2011] has proposed the design of modern FPGA based traffic light controller(TLC) system to manage the road traffic. The approach is by controlling the access to share the areas among multiple intersection and allocating effective time between various users, during peak and off-peak hours. The implementation is based on real time location where the existing traffic light controller system is basic fixed time method. The future improvement includes addition of other functions to the proposeddesign to suite various traffic conditions at differentlocations. The TLC design will include pedestrian crossing lights with the intention that the reliability of design can be much enhanced [18].

Shwetank Singh et al.,[2011] has proposed the project which deals with more efficient and effective way of handling the random and busy traffic patterns on roads. The purpose of this paper is to flash out the concept of non-dynamic traffic light controller. This AD-TLC concept will save time and will smoothen the traffic flow by avoidingheavy rush. The proposed TLC is more appropriate as road selection has been suitably prioritized on the basis of traffic intensity. The AD-TLC is designed using FSM including a total possible combinations of active sensors [19].

Jose E. Ortiz et al.,[2010] has proposed the simple traffic light controller design project was introduced to alleviate the shortcoming and to ensure the gain experience in solving implementation and interfacing problems of modern digital system. The intersection is completewith sensor to detect the presence of vehicles waiting at approaching the intersections. These includes FPGA for modeling and synthesis, finite state machine and signal synchronization. The simple traffic light controller design project turned out to be great success. This can be attributed to the implementation of controller as a series of milestone the use of realistic hardware testbench and allowing to innovate the simple controller by adding functionality to their design. This includes the use of verilog model to simulate and synthesize the digital system, understanding the fundamental concepts and application of FPGA and to develop expertise the microprocessor interfaces [20].

III. BLOCK DIAGRAM



IV. METHODOLOGY

The Block diagram of proposed Traffic light Controller which consists of north, east, west and south directions each with a set of three lights namely green, yellow and red. The diagram that represents the design of traffic light controller model. To distinguish each lane and the traffic signal lights, they are separated as North, East, South and West. Signal each lane have their set of traffic light signal as “Red, Yellow, and Green”.

Operation of the traffic light controller is similar to common traffic signal. Along with these specifications, each lane has a particular traffic light to represent the sensor of the corresponding road. Linear sensor or electromagnetic sensor which is suitable for the real time traffic light controller system. The first sensor detects the presence of vehicles and the second sensor determines the volume of the traffic which corresponds to the particular lane. Through the sensors, we can know the expected time for green signal, and when the signal light at each lane should be changed to green.

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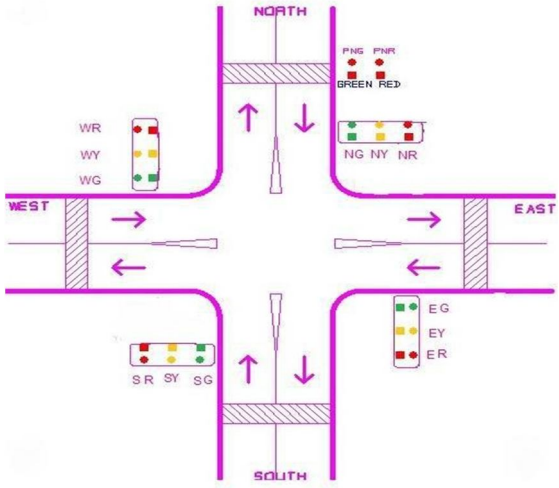
A. Structure Of The Road

A general road structure which consists of north, east, west and south directions each with a set of three traffic lights namely green, yellow and red. Green light direction will be ON when left, straight and right side is set to be free for traffic in that direction.

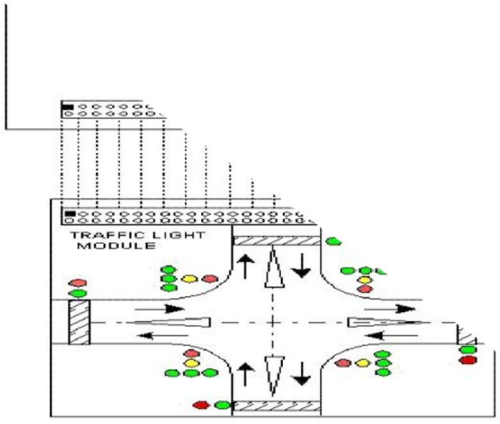


The figure represents the design of traffic light model. To distinguish each lane and the traffic light signal, they are labeled separately as North, East, South and West. Operation of this signallight is similar to common traffic light controller system. Along with these specifications, each lane has a light to represent a sensor for the corresponding road. Linear sensor or electromagnetic sensor is suitable for the design ofa real traffic light system. The first sensor detects the presence of vehicles and the second sensor determines the volume of the traffic corresponding to the particular lane. Through the sensors, we can identify the expected time for green signal to be ON and when the signal light at each lane shouldbe changed to green.

B. FPGA Implementation OF TLC:

Field Programmable Gate Arrays (FPGAs) are expensively used for quick prototyping and verification for the conceptual design and also it is used in electronic systems where the mask- production of a custom IC becomes really expensive due to small quantity. The use of FPGA's is increased to avoid the high costs for a custom VLSI design for a small quantity. Many system designs that can be used to built the custom silicon VLSI which are implemented in Field Programmable Gate Arrays.

Traffic light controller (TLC) is implemented using microcontroller FPGA, and ASIC design. FPGA have many advantages over microcontroller, and some of these advantages are; the speed, number of input/output ports and performance which are very important in TLC design, and at the same time ASIC design is more expensive than the FPGA.



Using Xilinx ISE tool, the code is dumped into Spartan-3E FPGA trainer kit and the output is considered which are more than the LEDs on the FPGA.

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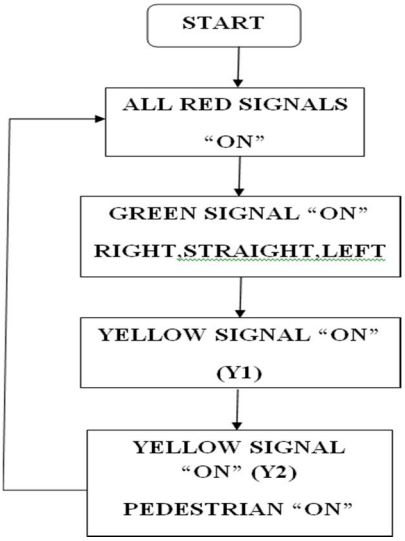
V. PROPOSEDMETHOD

A. Design of Traffic Light Controller:

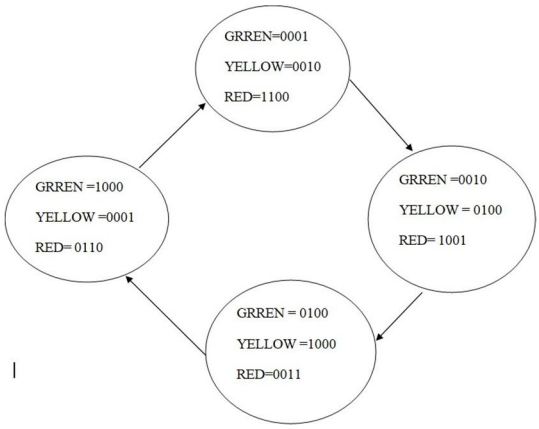
The Traffic Light Controller can be designed by starting it with some arbitrary assumptions. At North the traffic will be allowed to move, and followed by that traffic in the East, South and West direction will be allowed to move in a sequence. The advantage of writing Traffic Light Controller program is that in a program, that can be modifications as per the requirements and can be done easily (i.e.) the traffic on main road should be allowed for many time while for side roads the traffic should be allowed for less time; then the clock is divided in such a way that the timer for main road will be more and for side roads it will be less, this is because that the main road, has heavy traffic when compared to the side road .



In general TLC System will have three lights as (red, green and yellow) for each direction where red light represents that the vehicle has to be stopped, green light represents that the vehicle has to be moved and yellow light represents that the vehicle has to be stopped in few seconds.

B. State Diagram OF TLC

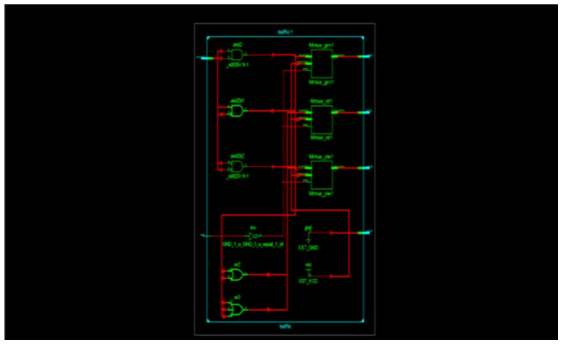
The TLC state diagram illustrates that the condition =00 and direction=00,the green light in north direction will be ON for few seconds and the red signal light in all other directions namely west, south and east will also be ON. When condition=01 and direction=00 then the yellow light (y1) will be ON for few seconds and the condition=01 yellow light (y2) and the pedestrian north will be ON ,then direction is incremented by one and condition is assigned to zero. So when condition=00 and direction=01, the green light in east direction will be ON for few seconds and all the red lights in other directions be ON. When condition=01 and direction=01 the yellow light (y1) will be ON for few seconds and the condition=01, yellow light (y2) pedestrian east will be ON and then the direction is incremented by one and condition is assigned to zero.



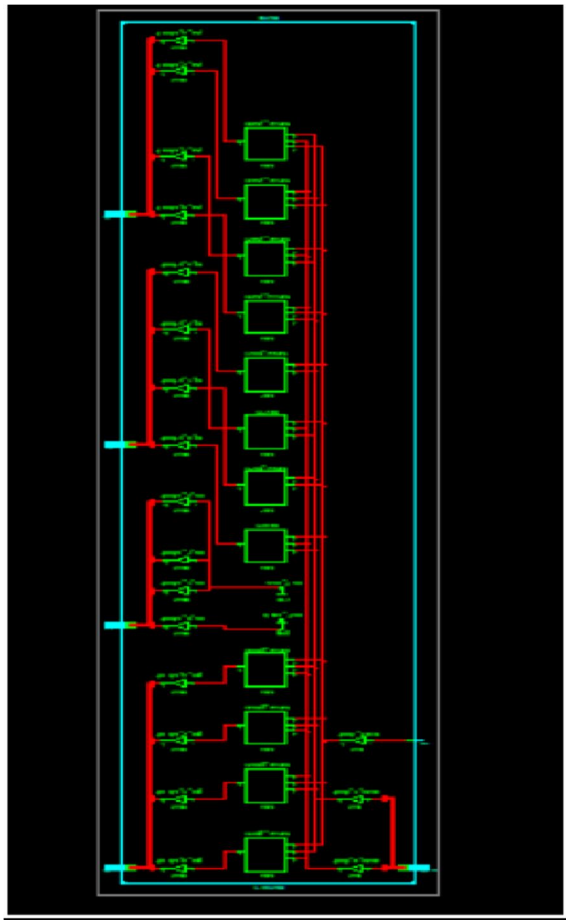
So whenever condition=00 and direction=10, the green light in south direction will be ON for few seconds and all red lights in other directions will be ON. Whenever condition=01 and direction=10 then yellow light (y1) will be ON for few seconds and when condition=01 yellow light (y2) and pedestrian south will be ON and then direction is incremented by one and condition is assigned to zero. So whenever condition=00 and direction =11, the green light in west direction will be ON for few seconds and all red lights in other directions will be ON. When the condition=01 and direction =11 then the yellow light (y1) will be ON for few seconds, and the condition=01, yellow light (y2) pedestrian west will be ON and then direction is assigned to 00 then the condition is assigned to zero. This sequence repeats and then the traffic flow will be controlled by assigning the time periods in all the directions.

VI. RSULTS

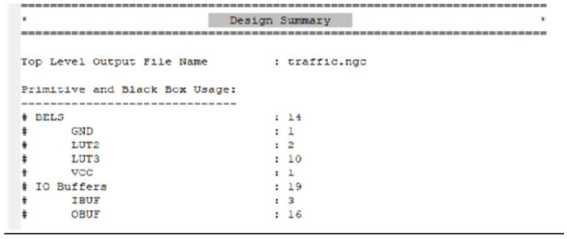
A. *RTL Schematic of TLC*



B. *Technology Schematic of TLC*

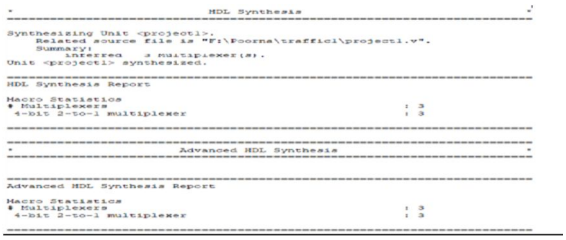


C. Design Summary OF TLC



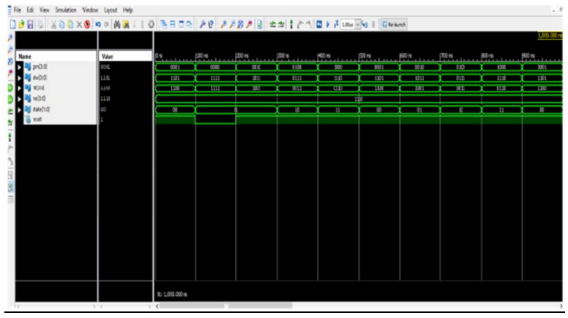
```
=========================================================================
*                      Design Summary                                   *
=========================================================================

Top Level Output File Name         : traffic.ngc

Primitive and Black Box Usage:
------------------------------
# BELS                             : 14
#      GND                         : 1
#      LUT2                        : 2
#      LUT3                        : 10
#      VCC                         : 1
# IO Buffers                       : 19
#      IBUF                        : 3
#      OBUF                        : 16
```

D. HDL Synthesis OF TLC



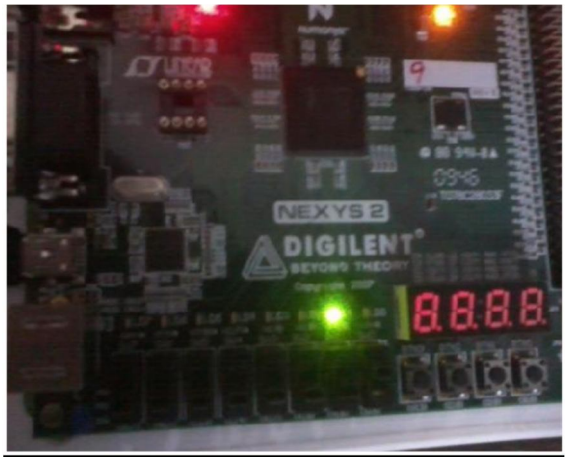
```
=========================================================================
*                      HDL Synthesis                                    *
=========================================================================
Synthesizing Unit <projecti>.
    Related source file is "F:\Poorna\traffic1\projecti.v".
    Summary:
        inferred   3 Multiplexer(s).
Unit <projecti> synthesized.

=========================================================================
HDL Synthesis Report

Macro Statistics
# Multiplexers                     : 3
 4-bit 2-to-1 multiplexer          : 3
=========================================================================

=========================================================================
*                      Advanced HDL Synthesis                           *
=========================================================================

=========================================================================
Advanced HDL Synthesis Report

Macro Statistics
# Multiplexers                     : 3
 4-bit 2-to-1 multiplexer          : 3
=========================================================================
```

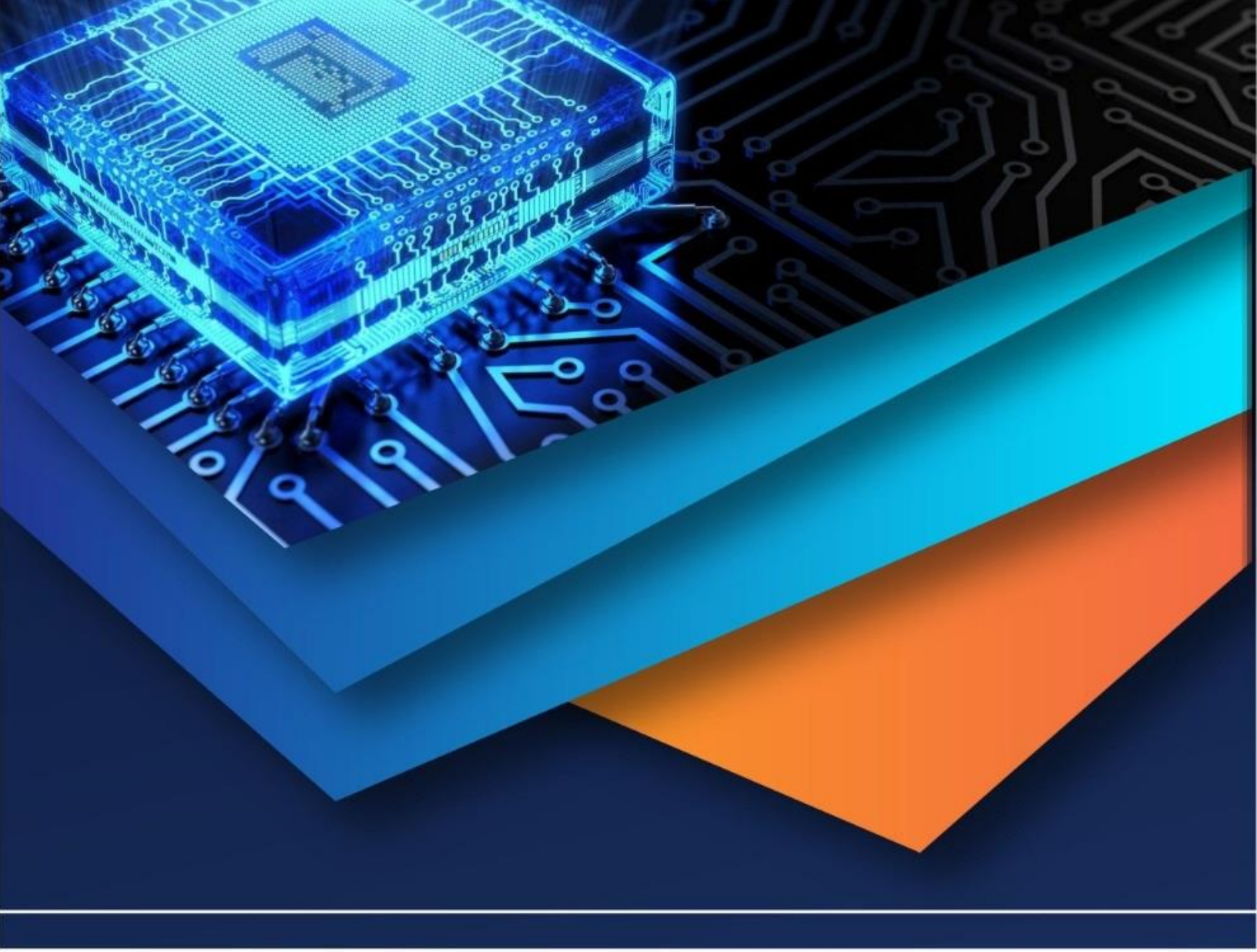
E. Wave Form of TLC



F. FPGA Implementation

The output of the TLC is verified with NEXYS 2FPGA. The output for Red Signal, Yellow and Green





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