DESIGN MODELLING OF TRAFFIC CONTROLLER USING VERILOG

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Abstract - The traffic in road crossings /junctions is controlled by switching ON/OFF Red, Green & Amber lights in a particular sequence. The Traffic Light Controller is designed to generate a sequence of digital data called switching sequences that can be used to control the traffic lights of a typical four roads junction in a fixed sequence. It is also proposed to implement the day mode and night mode operations. It plays more and more important role in modern management and control of urban traffic to reduce the accident and traffic jam in road. It is a sequential machine to be analyzed and programmed through a multistep process. The device that involves an analysis of existing sequential machines in traffic lights controllers, timing and synchronization and introduction of operation and flashing light synthesis sequence. The methods that are used in this project are design the circuit, write a coding, simulation, synthesis and implement in hardware. In this project, XILINX Software was chosen to design a schematic using schematic edit, writes a coding using Verilog HDL (Hardware Description Language).

Keywords: Traffic Light Controller, Timing and Synchronization, XILINX Software.

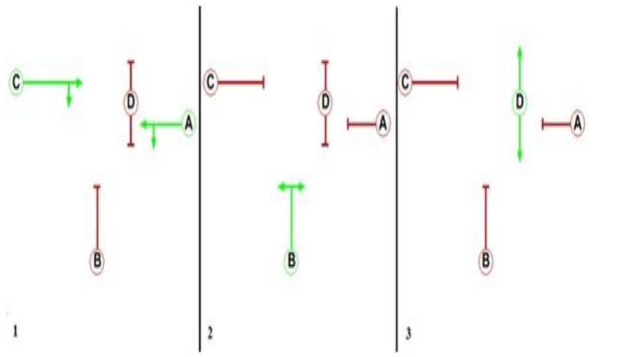
I. INTRODUCTION

Traffic congestion is a severe problem in many modern cities around the world. Traffic congestion has been causing many critical problems and challenges in the major and most populated cities. To travel to different places within the city is becoming more difficult for the travelers in traffic. Due to these congestion problems, people lose time, miss opportunities, and get frustrated. 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 goes 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 we need to change the system rather than making new infrastructure twice. Therefore many countries are working to manage their existing transportation systems to improve mobility, safety and traffic flows in order to reduce the demand of vehicle use. 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. The time of allocation is fixed from east to west or opposite way and from north to south way in crossroads. 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.

II. LITERATURE SURVEY

The normal function of traffic lights requires more than slight control and coordination to ensure that traffic and pedestrians move as smoothly, and safely as possible. A variety of different control systems are used to accomplish this, ranging from simple clockwork mechanisms to sophisticated computerized control and coordination systems that self-adjust to minimize delay to people using the junction.

A. PHASES AND STAGES:



This junction has three vehicle phases (A, B and C) and a pedestrian phase (D). The phases operate together in three stages (1, 2 and 3). Moving phases are shown in green and stopped phases are shown in red.

Traffic controllers use the concept of **phases**, which are directions of movement grouped together.[4][5] For instance, a simple T-junction may have three vehicle movement phases, one for each arm of the junction. There may be additional phases for other movements such as pedestrians, cyclists, bus lanes or tramways.

A **stage** is a group of non-conflicting phases which move at the same time. [6]

In Australia and New Zealand, the terminology is different. A "phase" is a period of time during which a set of traffic movements receive a green signal - equivalent to the concept of a "stage" in UK and USA. One electrical output from the traffic signal controller is called a "signal group" - similar to the UK and USA concept of "phase".

B. TRAFFIC CONTROLLER SYSTEMS:

A traffic signal is typically controlled by a controller mounted inside a cabinet.[7] Some electro-mechanical controllers are still in use (New York City still had 4,800 as of 1998, though the number is lower now due to the prevalence of the signal controller boxes[8]). However, modern traffic controllers are solid state. The cabinet typically contains a power panel, to distribute electrical power in the cabinet; a detector interface panel, to connect to loop detectors and other detectors; detector amplifiers; the controller itself; a conflict monitor unit; flash transfer relays; a police panel, to allow the police to disable the signal; and other components.[7]

Figure: Computerized traffic control box

In the United States, controllers are standardized by the NEMA, which sets standards for connectors, operating limits, and intervals.[7] The TS-1 standard was introduced in 1976 for the first generation of solid-state controllers.[9]

Solid state controllers are required to have an independent *conflict monitor unit* (CMU), which ensures fail-safe operation. The CMU monitors the outputs of the controller, and if a fault is detected, the CMU uses the flash transfer relays to put the intersection to *FLASH*, with all red lights flashing, rather than displaying a potentially hazardous combination of signals. The CMU is programmed with the allowable combinations of lights, and will detect if the controller gives conflicting directions a green signal, for instance.

In the late 1990s, a national standardization effort known as the Advanced transportation controller (ATC) was undertaken in the United States by the Institute of Transportation Engineers.[9] The project attempts to create a single national standard for traffic light controllers. The standardization effort is part of the National Intelligent transportation system program funded by various highway bills, starting with ISTEA in 1991, followed by TEA-21, and subsequent bills. The controllers will communicate using *National Transportation Communications for ITS Protocol* (NTCIP), based on Internet Protocol, ISO/OSI, and ASN.1.[9]

Battery backups installed in a separate cabinet from the traffic controller cabinet on the top. Traffic lights must be instructed when to change stage and they are usually coordinated so that the stage changes occur in some relationship to other nearby signals or to the press of a pedestrian button or to the action of a timer or a number of other inputs.

C. FIXED TIME CONTROL:

Pedestrian traffic signal in Taiwan, featuring a "Walking green man" below a countdown display where the "Red Man" once stood.

In traffic control, simple and old forms of signal controllers are what are known as electro- mechanical signal controllers. Unlike computerized signal controllers, electro-mechanical signal controllers are mainly composed of movable parts (cams, dials, and shafts) that control signals that are wired to them directly. Aside from movable parts, electrical relays are also used. In general, electro-mechanical signal controllers use dial timers that have fixed, signalized intersection time plans. Cycle lengths of signalized intersections are determined by small gears that are located within dial timers. Cycle gears, as they are commonly known, range from 35 seconds to 120 seconds. If a cycle gear in a dial timer results in a failure, it can be replaced with another cycle gear that would be appropriate to use. Since a dial timer has only one signalized intersection time plan, it can control phases at a signalized intersection in only one way. Many old signalized intersections still use electro-mechanical signal controllers, and signals that are controlled by them are effective in one way grids where it is often possible to coordinate the signals to the posted speed limit. They are however disadvantageous when the signal timing of an intersection would benefit from being adapted to the dominant flows changing over the time of the day.[11]

D. COORDINATED CONTROL:

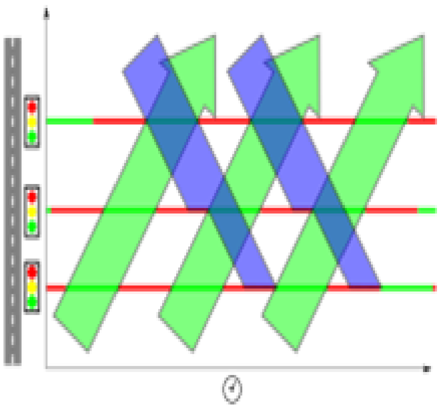


Diagram demonstrating that when traffic lights are synchronised for traffic travelling in one direction (green arrows), the traffic in the other direction is not necessarily synchronised (blue arrows).

Benefits include:[15][16]

- Increasing the traffic handling capacity of roads
- Reducing collisions and waiting time for both vehicles and pedestrians[17]
- Encouraging travel within the speed limit to meet green lights
- Reducing unnecessary stopping and starting of traffic - this in turn reduces fuel consumption, air and noise pollution, and vehicle wear and tear
- Reducing travel time

E. ADAPTIVE CONTROL:

RFIDE-ZPass reader attached to the pole and its antenna (right) used in traffic monitoring in New York City by using vehicle re-identification method.

F. OTHER TYPES OF CONTROL:

- **Failures**: If power is still available, a flashing amber light is used to warn of an intersection. Methods to distinguish the main road from the secondary road (and hence right of way) include using yield (give way) signs, stop signs or a flashing red light on the secondary road as well as written signage. In some countries including Australia, the road rules outline procedures such as giving way to the right.
- **Part-time operation**: Some traffic lights will not operate at night or when traffic is very light. Some may only operate at particular set times (e.g. during working hours of a major factory) or only during special events such as sports or exhibitions. When not operating, the same measures as with failures are used. Part-time operation has advantages and disadvantages.[28][29]
- **Railroad preemption**: Traffic signals are activated to coincide with the approach of a train, often where the intersection is near a rail crossing. See also Railroad preemption
- **Bus and Transport Priority**: Traffic signals are activated to coincide with the arrival of a bus or tram along a busway, bus lane or tramway. See also Bus priority
- **Emergency Vehicles** Some lights outside of fire or rescue stations have no green, as they may turn only amber and then red when fire trucks, ambulances, or other emergency vehicles or the like are exiting the station en route to an emergency. See also Traffic signal preemption
- **Speed signs** are a rarely used variant to give drivers a recommended speed to approach the next traffic light in its green phase.

III. IMPLEMENTATION OF TRAFFIC LIGHT CONTROLLER

A. DESIGN OF TRAFFIC LIGHT CONTROLLER:

Traffic Light Controller can be designed by starting with some arbitrary assumptions. At first the North traffic will be allowed to move and then traffic in the East, South and West direction will be allowed to move in sequence. The advantage of writing Traffic Light Controller program is that in a program, modifications as per requirements can be done easily i.e., suppose the traffic on main road should be allowed for more time and for side roads the traffic should be allowed for less time; then the clock is divided in such a way that for main road the clock period will be more and for side roads the clock period will be less, this is because the main road traffic is heavy when compared to the side road traffic. In general TLC System will be having three lights (red, green and yellow) in each direction where red light stands for traffic to be stopped, green light stands for traffic to be allowed and yellow light stands for traffic is going to be stopped in few seconds.

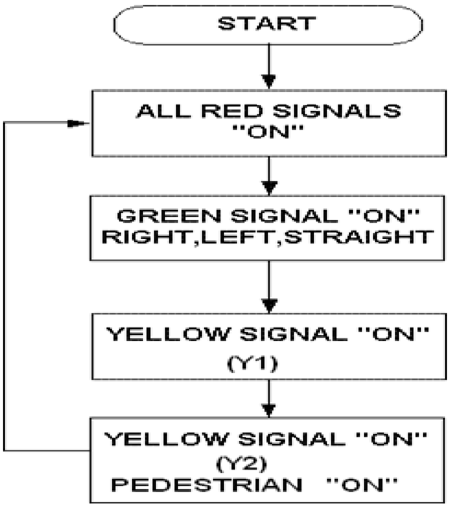


Fig TLC Flow Chart

B. EXPLANATION OF TRAFFIC LIGHT CONTROLLER

In this structure, there are four traffic signals, represented by R1, R2, R3 and R4 to be controlled. All the four signals have same priority as they all are main roads.

First of all the signal controller is in the reset mode where in the signal of road (R1) is green whereas all the other roads R2, R3 and R4 are red. This state we have assigned as S0.

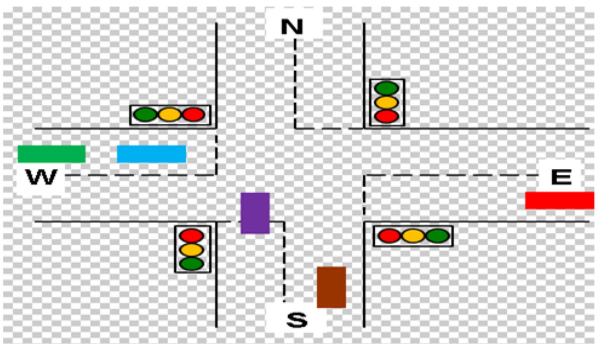


Fig: - Traffic Signals at Junction

Later the controller sends the control to state S1 where the R1 is yellow whereas all the other signals are still red only. In this state the controller checks whether the sensor at road R2 which is X2 is low or not. If the sensor gives a low signalling that there is no traffic on that road, then that signal on road R2 is skipped transferring control to the state S4 where signal on road R3 is turned whereas rest of the signals are showing red. On the hand if the traffic is present on the road R2 then the control is sent to state S2 which switches on the signal on road R2 to green and rest of the signals are red only when the control is with state S2 after showing the green signal the signal light changes from green to yellow for signal on the road R2 while all the other signals continue to be in red light mode only which is the operation of state S3.

Again when the controller is in state S3 it checks for the response of sensor X3 on road R3. If the output of sensor is low the control of the system will be transferred to state S6 skipping the working of the signal on road R3 otherwise the control is given to corresponding next state S4.

When in S4 the traffic signal of road R3 turns green on the other hand the signals of roads R1, R2 and R4 remain red itself. The control is then transferred to state S5.

When the control is with state S5 it checks for the output of the sensor X4 on the road R4. Depending on the output of X4 the further state change takes place accordingly. If low then the control is transferred to state S0 skipping the operation of the signal on road R4 otherwise the control is with the S6. When the controller is in state S5 there is change of signal on road R3 from green to yellow.

When the control is with state S6 the signal of road R4 turns green whereas all the signal turn or remain in red signal only. Thee control is then shifted to state S0.

In state S7 the signal of road R4 turns from green to yellow. Simultaneously the sensor on the first road R1 which is X1 is checked for its output. If the signal is low then the control is shifted directly to state S2 otherwise the control is shifted to default state S0.

These states are not mandatory. The number of states, the order of the lights and the delay can be specified by the user.

C. TLC State Diagram

The TLC state diagram shown in Fig 2.3 illustrates that whenever cnt=00 and dir=00,then green light in north direction will be ON for few seconds and red signal light in all other directions namely west, south and east will be ON. When cnt=01 and dir=00 then yellow light (y1) will be ON for few seconds and when cnt=01 yellow light (y2) and pedestrian north will be ON and then dir is incremented by one and cnt is assigned to zero. So when cnt=00 and dir=01, the green light in east direction will be ON for few seconds and all red lights in other directions be ON. Whenever cnt=01 and dir=01 then yellow light (y1) will be ON for few seconds and when cnt=01 yellow light (y2) and pedestrian east will be ON and then dir is incremented by one and cnt is assigned to zero.

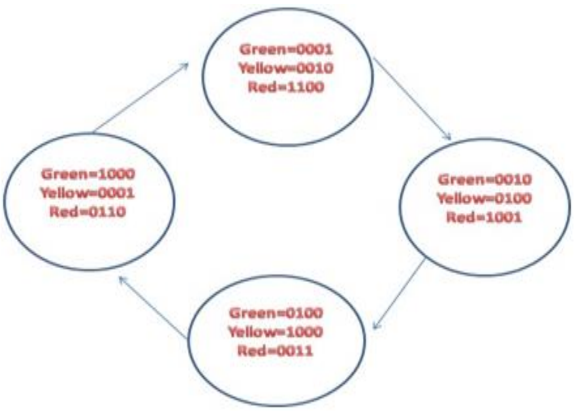


Fig:- TLC State Diagram

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

IV. SIMULATION RESULTS

RTL Schematic

The below figure shows the RTL Schematic of the Traffic Light Controller.

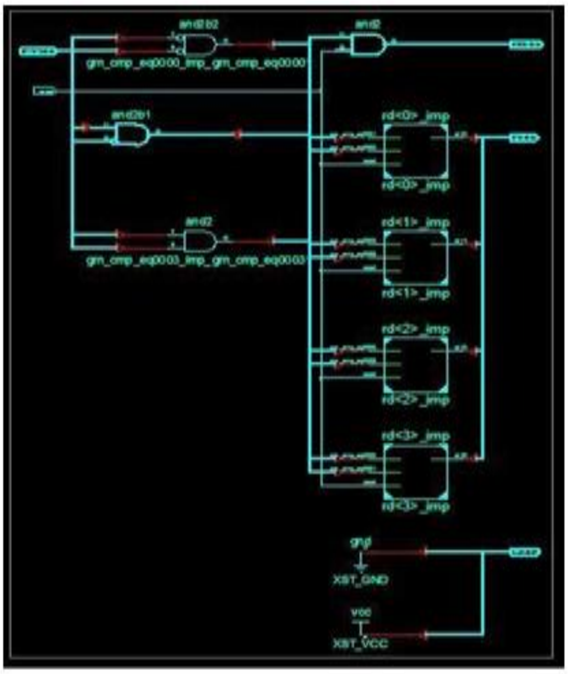


Fig: - RTL Schematic

Technology Schematic

The below figure shows the Technology Schematic of the Traffic Light Controller.

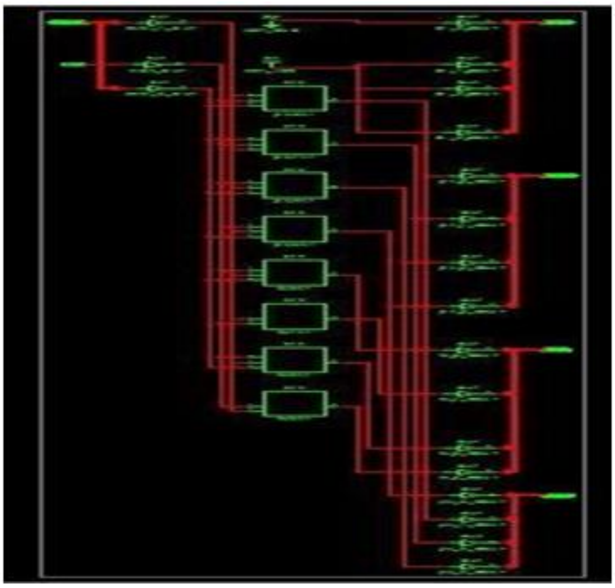


Fig: - Technology Schematic

Wave Form

The below figure shows the Wave form of the Traffic Light Controller when the test bench is applied to the source code.

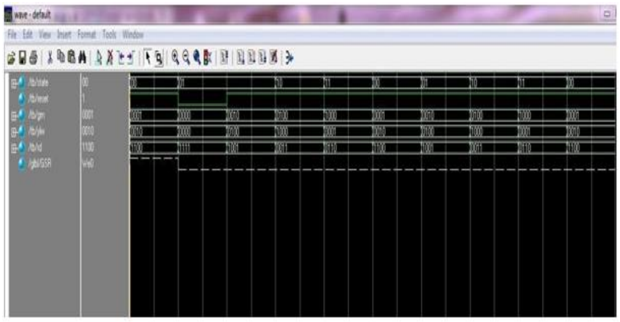


Fig: - Wave Form

V. CONCLUSION AND FUTURE SCOPE

The modern ways of multi-way traffic management improves the traffic condition up to a large extent. Advanced signaling controllers contribute to the improvement of the urban traffic; which is proportional to the complexity of the controller. These more complex controllers can be well handled using states machines. Methods to reduce the states in the state machine also help in reducing the required hardware thus leading to low power and area efficient design.

The future scope of this project is it can be directly applied in real time by employing more number of such circuits.

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