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SMART TRAFFIC LIGHT CONTROL SYSTEM

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Abstract: The existing traffic light controller used almost in every city, towns, or villages utilizes a basic fixed-time method in which the time allotted to the traffic signal lights are fixed irrespective of the traffic density in that path (i.e., whether low or high). This method is inefficient and almost always leads to traffic congestion during peak hours while drivers are given unnecessary waiting time during off-peak hours. The proposed design is a more universal and intelligent approach to the situation and has been implemented using FPGA. In this project, we have proposed a design of FPGA-based Traffic Light Control (TLC) System to manage the road traffic. The approach is by controlling the access to areas shared among multiple intersections and allocating effective time between various users, during peak and off-peak hours. Theoretically the waiting time for drivers during off-peak hours has been reduced further, therefore making the system better than the one being used at the moment. Future improvements include addition of other functions to the proposed design to suit various traffic conditions at different locations.

Keywords: FPGA (Field Programmable Gate Array), Infrared Sensor, FSM (Finite State Machine), VHDL, Xilinx ISE.

I.INTRODUCTION

Traffic lights are integral part of modern life. Their proper operation can spell the difference between smooth flowing traffic and four-lane gridlock. Proper operation entails precise timing, cycling through the states correctly, and responding to outside inputs. The traffic controller is designed to meet a complex specification. That specification documents the requirements that a successful traffic right controller must meet. It consits of an operation specification that describes the different functions the controller must perform, a user interface description specifying what kind of interface the system must present to users, and a detailed protocol for running the traffic lights. Each of these requirements sets imposed new constraints on the design and introduced new problems to solve. The controller to be designed controls the traffic lights of a busy highway (HWY) intersecting a side road (SRD) that has relatively lighter traffic load.

II.PROPOSED SYSTEM

The below shown is the **road intersection** for our proposed system and block diagram of "**Smart Traffic Light Control System**".

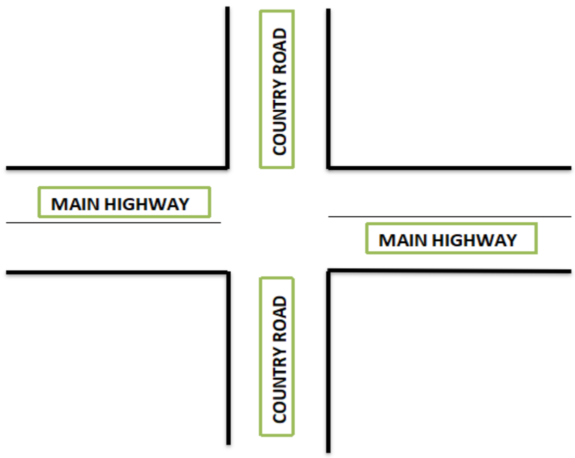

Fig. 1: Road Intersection

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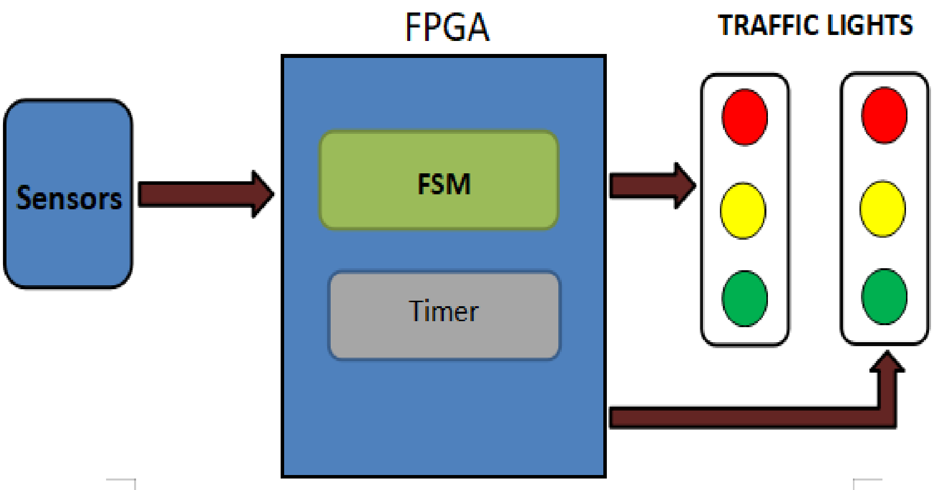

Fig. 2: Block Diagram of Smart Traffic Light Control System

1. FPGA Development Board: The Basys2 board is a circuit design and implementation platform that anyone can use to gain experience building real digital circuits. Built around a Xilinx Spartan-3E Field Programmable Gate Array and an Atmel AT90USB2 USB controller, the Basys2 board provides complete, ready-to-use hardware suitable for hosting circuits ranging from basic logic devices to complex controllers. A large collection of on-board I/O devices and all required FPGA support circuits are included, so countless designs can be created without the need for any other components.

Four standard expansion connectors allow designs to grow beyond the Basys2 board using breadboards, user-designed circuit boards, or Pmods (Pmods are inexpensive analog and digital I/O modules that offer A/D & D/A conversion, motor drivers, sensor inputs, and many other features).

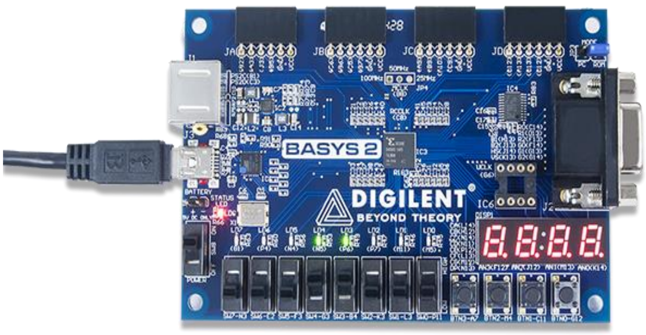

Fig. 3: FPGA Development Board

2. IR Sensor Module: Infrared technology addresses a wide variety of wireless applications. The main areas are sensing and remote controls. In the electromagnetic spectrum, the infrared portion is divided into three regions: near infrared region, mid infrared region and far infrared region. It has three pins, namely, power supply input, ground and output. It consists of Op-Amp (LM 358), variable register, output LED, transmitter and receiver.

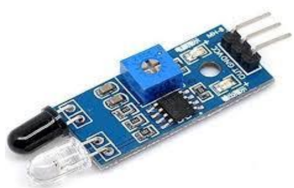

Fig. 4: IR Sensor Module

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3. LED: LED (Light Emitting Diode) is a two terminal semiconductor device. The functionality of LED is as same as normal diode but it emits light when current passes through it. It is used in most of the electronic circuits as a sign or visual representation to the normal human to know that circuit is working properly. We have lot of applications using LEDs. They are used in advertisement hoarding, Electronic devices, displays, night lamps, etc.

Fig. 5: LED

4. Xilinx ISE: Xilinx ISE(Integrated Synthesis Environment) is a discontinued software tool from Xilinx for synthesis and analysis of HDL designs, which primarily targets development of embedded firmware for Xilinx FPGA and CPLD integrated circuit (IC) product families. Use of the last released edition from October 2013 continues for in-system programming of legacy hardware designs containing older FPGAs and CPLDs otherwise orphaned by the replacement design tool, Vivado Design Suite.

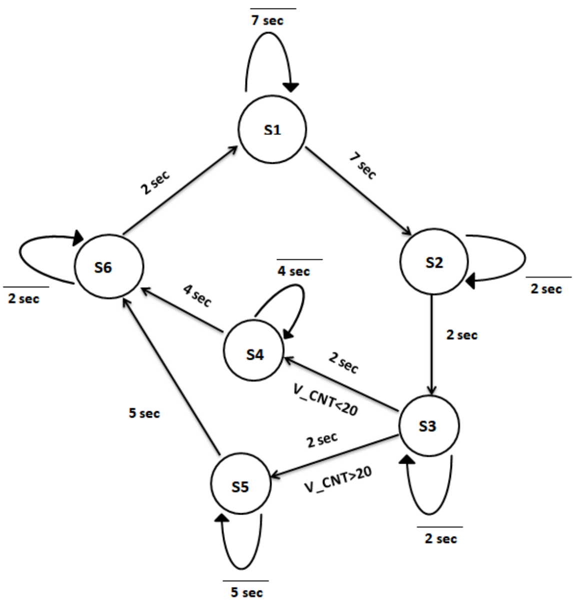
ISE enables the developer to synthesize ("compile") their designs, perform timing analysis, examine RTL diagrams, simulate a design's reaction to different stimuli, and configure the target device with the programmer. Other components shipped with the Xilinx ISE include the Embedded Development Kit (EDK), a Software Development Kit (SDK) and Chip Scope Pro. The Xilinx ISE is primarily used for circuit synthesis and design, while ISIM or the ModelSim logic simulator is used for system-level testing.

III.SIGNIFICANCE

One of the advantages of this design over the existing method is the waiting time of drivers during off-peak hours has been reduced, means that the normal design cycle (using fixed–time technique) has been reduced notably, thus ameliorate reliability and flexibility of the Traffic Light Controller (TLC).

The functionality of this design can be easily enhanced. For example, more intelligent design will include camera interfacing which will detect if any car breaks the traffic rule, which will serve for security purpose and emergency services.

IV.STATE DIAGRAM



STATE	SIGNALS	
S1	Highway- Green	Country- Red
S2	Highway- Yellow	Country- Red
S3	Highway- Red	Country- Red
S4	Highway- Red	Country- Green
S5	Highway- Red	Country- Green
S6	Highway- Red	Country- Yellow

Fig. 6: State Diagram

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V.WORKING

The main goal of this project is to manage the traffic movement of four intersecting roads (a one-way Country Road and two cross-way Main Highway Roads). The Traffic Light Controller setup will be installed for the one-way country road only. It will be working in synchronization with the traffic lights of the other three paths (which will be using the regular currently used circuitry for its working. We will be simulating this operation using a 5-state FSM on a software interface, and finally we will be dumping this into a suitable FPGA board. Here, we are considering a "Plus" junction consisting of a one-way Country Road installed with Traffic Light Controller. Firstly, a "Sensor" circuitry will be detecting the number of vehicles present in the Country Road path. The output of this circuitry will be given out to the "FSM and Timer" circuitry, based on which it will be allotting the "time" for its path light to stay in "Green" condition. This time will be allotted to it based on the traffic density in this path. This whole circuitry will be completing its process (starting from getting the count, to generating the "time" at the output) during the transition of the "Country Road's light" from Red to Yellow.

In the FSM state diagram, consider the 5 states as S1, S2, S3, S4, and S5. For the demonstration purpose, we are using the order of time few seconds only. Initially, the FSM will continue in state S1 for 7 seconds (i.e., until the HIGHWAY road light is Green and the COUNTRY road light is Red). After 7 seconds, it will make transition into S2 state where the HIGHWAY road light will be yellow and COUNTRY road light will be Red. It stays in this state for 2 seconds, after which it makes transition into S3 state where the HIGHWAY road light will turn Red and COUNTRY road light will also be Red. It stays in S3 state for another 2 seconds. At this point, the sensor circuitry will come into action to get the count of traffic from the COUNTRY road path. The more will be the count of the traffic, the more time will be allotted to its light to stay in Green condition. In the S3 state, if the vehicle count comes out to be less than 20 (assumed value), it will move to S4 state after 2 seconds, and if the vehicle count comes out to be greater than 20, then it will move to the S5 state after 2 seconds. Now, in the S4 state, the HIGHWAY road light will be Red and the COUNTRY road light will be Green and it will stay in the same state for 4 seconds (assumed value). And, in the S5 state, the HIGHWAY road light will be Red and the COUNTRY road light will be Green. But now, since the traffic density is more, so the time allotted will be more, hence it will stay in the same S5 state for 5 seconds (assumed value). Now, after this S4 (or, S5) state, it will make transition to S6 state after 4 (or, 5) seconds where the HIGHWAY road light will be Red and COUNTRY road light will be Yellow. It will stay in the same state for 2 seconds after which it will make its transition back to S1 state.

For the implementation of this idea, we are using the Basys-2 FPGA development board, and all the programming and simulations was done on "Xilinx ISE" and the "ModelSim" software. For getting the count of the traffic, we have used IR (Infra-Red) module which operates on 5 Volts DC supply and has range up-to 20 centimetres. This module is used just for the demonstration purpose. For the practical implementation of this idea, we will be requiring an IR based circuit having range of up to few tens of meters, or may be around 100 meters. Apart from this, many other techniques may also be used for getting the count of traffic like some Machine Learning model which will be more advantageous in terms of the accuracy of the traffic count. Or, a pressure sensor strip may also be used, but the accuracy of traffic count will be minimum.

VI.SIMULATION RESULTS

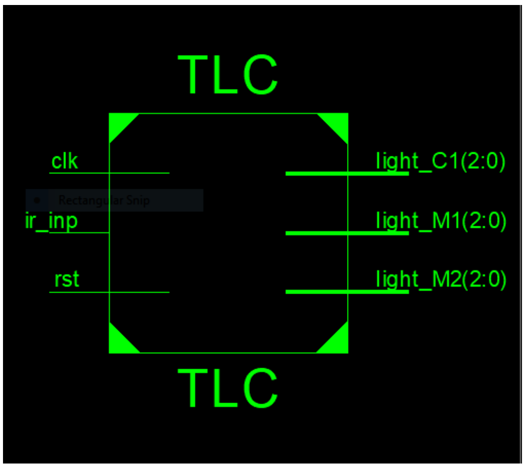

Fig. 7: RTL Schematic of Smart Traffic Light Control System

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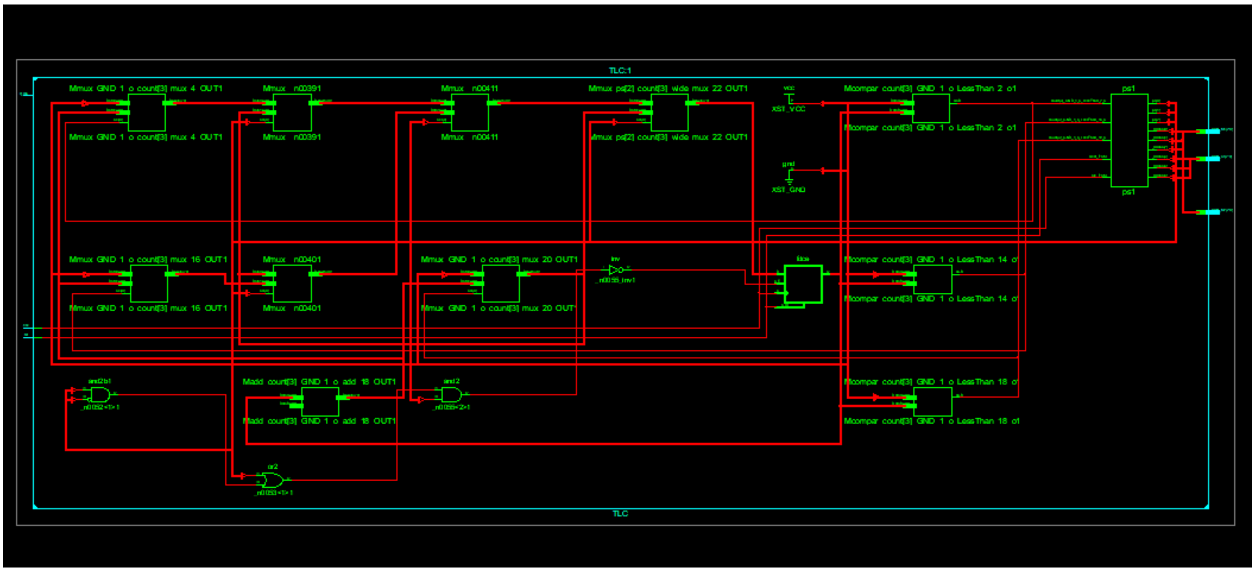

Fig. 8: Detailed RTL Schematic of Smart Traffic Light Control System

VII.Simulation Waveforms

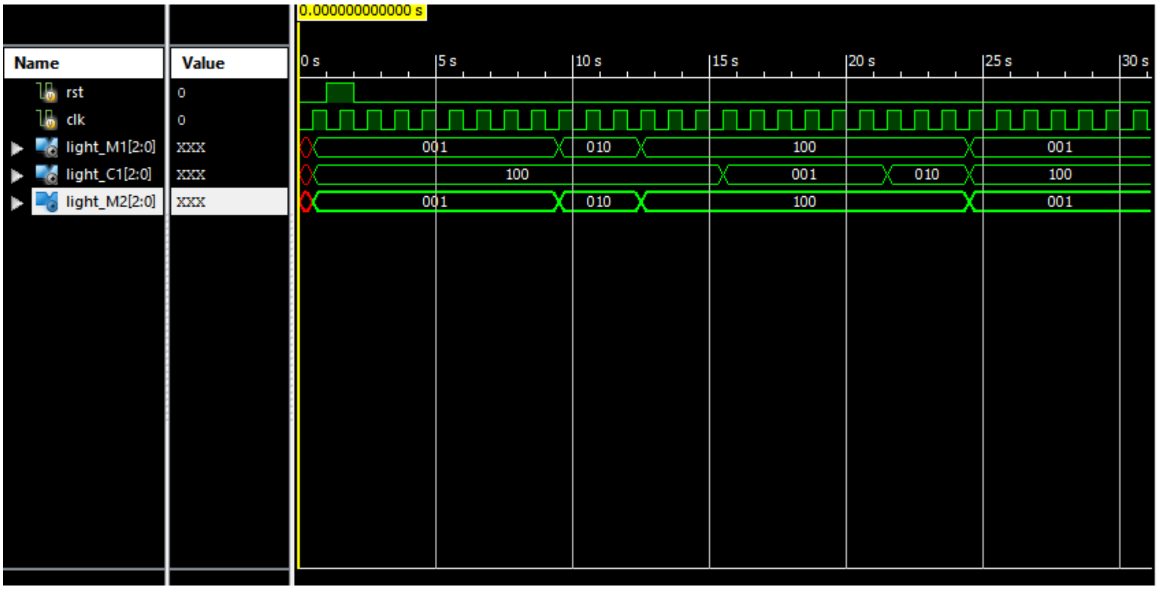

Fig. 9: Waveforms for state transition

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