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Street Light Controller Including Automatic Traffic Light Controller System Implementation on FPGA

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Abstract— The number of vehicles has greatly expanded over time and is continually growing. Due to traffic congestion, a sizable amount of working hours must be spent on the roads, which has an indirect negative influence on the economy and leads to preventable road accidents that end in fatalities. While metropolitan infrastructures are developing much more slowly, the number of vehicles is rising. We require a system that can successfully manage such a circumstance. A system that can efficiently manage traffic is what we call an automatic traffic control system. Moreover, a system for automatic street lights is built within. This suggested concept tries to automate traffic regulation based on density and a controller for automatic street lights that only come on at night. It detects vehicles by using IR (Infra Red) sensors in every direction. IR sensor modules for traffic lights and an LDR sensor module for streetlights provide the inputs, respectively. Verilog HDL is used to implement the solution, and Xilinx Vivado is used to simulate it. An FPGA has this suggested model pre-programmed (Field Programmable Gate Array).

Keywords- Traffic Control System; Street Light system; IR (Infra Red); LDR (Light Dependent Resistor);Verilog HDL;FPGA.

I. INTRODUCTION(*HEADING 1*)

Using Verilog and FPGA (Field Programmable Gate Array) technology, an automated traffic signal and street light system provides a intelligent solution for traffic control and energy savings [1]. As traffic volume and environmental conditions change, the system automatically modifies the lighting to best manage traffic while utilizing the least amount of electricity[2-4]. An FPGA-based controller powers this system, which receives data from a variety of sensors including traffic volume sensors (IR) and LDR sensors[5]. The controller creates output signals to manage traffic and street lights after analyzing the sensor data.

Street lights and traffic are both vital in today's society for controlling traffic flow [6]. By including the necessary sensors, automation of these systems facilitates work that requires no human intervention[7-9]. Even though there have always been numerous automated systems, the FPGA implementation gives the system greater flexibility and performance compared to other traditional methods [10]. An integrated circuit (IC) known as a field programmable gate array is used to construct application-specific ICs as well as the necessary digital circuits [11]. Either Verilog or VHDL was utilized as the hardware description language for any system constructed on an FPGA.

Logic circuits are designed using the Verilog hardware description language, and the digital logic design is implemented using FPGA technology. Signals can be generated to regulate traffic and street lights by real-time processing of sensor data on the FPGA [12]. Compared to conventional traffic and street light systems, this system has a number of benefits, including reduced congestion through improved traffic flow, energy [13] efficiency through adjusting light intensity in accordance with ambient light level, and simple integration into existing infrastructure for smart city applications [14]. For extra benefits, the current infrastructure may easily be expanded with this scalable and affordable solution. In this publication, we present the design and implementation of a Verilog HDL and FPGA-based integrated automated traffic and street light system.

II. COMPONENTS

The components used in this model are:
1. Edge artix 7 XC7A35T-1CPG236CFPGA.
2. IR sensor digital module
3. LDR sensor digital module.

A. Xilins Edge artix 7 XC7A35T-1CPG236C FPGA

An integrated circuit called a field-programmable gate array (Figure 1) can be programmed and reprogrammed to carry out a variety of tasks related to digital logic [15]. In order to create intricate digital circuits, FPGAs use a large number of customizable logic blocks (CLBs) coupled in a variety of ways [16]. Each CLB in an FPGA is made up of a flip-flop and a customizable logic element (CLE), and an FPGA typically has hundreds of them. The flip-flop synchronises data with the device's clock signal while storing data in the CLE, which may be programmed to do logic operations including AND, OR, XOR, and NOT.
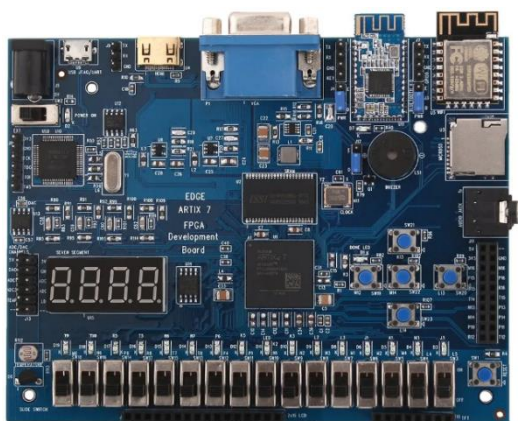
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Figure 1. Edge Artix 7 FPGA

Several Core Loaded Blocks (CLBs) are present in an FPGA and can be combined in a variety of ways to create intricate digital circuits [17]. The designer can maximize performance while lowering power consumption for each CLB pair by implementing these connections utilizing programmable routing resources like cables and switches [18]. Configurable logic blocks (CLBs), the building blocks of internal digital circuitry, are implemented by FPGAs using LUTs. Several LUTs that can be programmed to execute different logic operations are present in each CLB.

B.   IR Sensor Digital Module

Figure 2. IR Sensor Digital Module

A digital infrared sensor module(Figure 2) is a piece of technology used to track infrared emissions from objects. It is made up of a sensor and processing unit that turns [19] the IR signal that is received into digital output. These modules are frequently used in applications for distance measurement, temperature sensing, and motion detection. The infrared sensor digital module measures temperature variations brought on by an object's emission of infrared radiation. This radiation is absorbed by a detector, which then transforms it into an electrical signal. In order to remove noise and interference, the processing unit then amplifies and filters this signal. Finally, it outputs it as a digital output signal that can be read by any digital device.

C.   LDR Sensor Digital Module

Electronic sensors known as LDRs (Figure 3) adjust their resistance in response to the amount of light. One that produces a digital output signal is referred to as a digital module [20]. These two technologies are used by an LDR sensor digital module to provide a digital output signal based

on light detected by the LDR sensor. A signal processing circuit and an LDR sensor typically make up the digital LDR sensor module.

Figure 3. LDR Sensor Digital Module

An electronic device, such as a microcontroller, can read the digital signal that the signal processing circuit transforms from the analogue signal from the LDR sensor. Following that, further circuits or devices depending on detected light could be activated using this digital output signal.

III. METHODS

The methodology of work for this project can be explained in 3 steps. They are

1. Logic Analysis
2. Input Condition Consideration
3. Circuit connection
4. Simulation & Device Programming

A.   Logic Analysis

The logic for the proposed model is based on the operation of the shift registers. A shift register is a sequential circuit which shifts the data it stores as per the stated interval. The shift register logic is used to change the state from one output to the other. Here the outputs are the LEDs. This system consists of total of 12 LEDs for the traffic light operation and 4 additional LEDs for the street lights [21]. In addition to this, it also takes the help of a counter program. This counter increments it's its value down from zero with 1 at every stated interval. The use of a counter gives the clock divider. The actual clock frequency of the EDGE Artix 7 is 50Mhz. At that speed, the switching of LEDs to ON and OFF cannot be seen. So with the aid of a clock divider program, we can obtain a clock which is of a lower frequency. It is employed to see the actual switching of the lights in real-time.

B.   Input Condition Consideration

There are many input conditions. Some of them are i) When there is an equal amount of traffic in all directions, ii) When there is more traffic in some directions while less traffic in remaining directions, iii) When there is traffic in some directions while no traffic at all in the remaining directions. This traffic light system meets the requirement of every possible traffic scenario at the four-road junction [22]. With the street light system, the operation can be explained in simple terms. When the ambient light in the surroundings goes down than the given threshold limit, it gives an output pulse of logic high. This pulse is the trigger that says that it is getting dark. At receiving the input from the LDR module, the

3113

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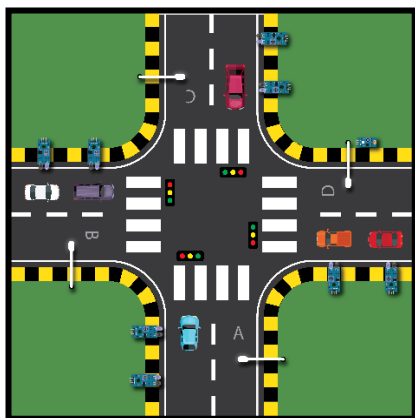additional 4 LEDs used for the street lights stated previously are turned ON

Figure 4. Four road junction
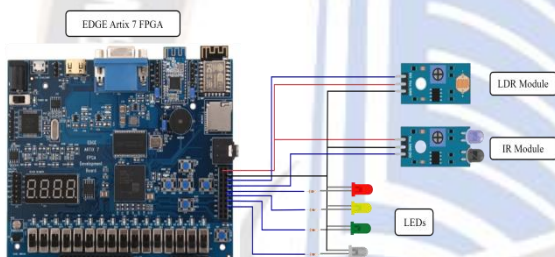
C.   Circuti Connetion

Figure 5. System circuit connection

The circuit connection for the proposed system is given in Figure 5. With the general purpose package pins of the FPGA, we can connect the external components as per the requirement. Here, we connected the sensor modules namely the IR and LDR modules to the power pin which is 5v we have on board and the ground pins are connected to the GND on the board [23]. The D0 pin indicates the output from the sensor modules. Finally the LEDs are connected to the general purpose pins as well but with the aid of a resistor as the LED's we used work below 5 volts level. All the LEDs can be connected to a common GND pin. Only the connections are made on the board andthe nature of the pin i.e., whether to act as input or output can be configured at the time of programming the devie.

D.   Simulation & Device Programming

The code is implemented in Verilog HDL. The FPGA can be programmed either with VHDL or Verilog HDL [24]. We used Xilinx Vivado for the simulation part. We tested all the conditions by writing a test bench for all the possible input conditions. For programming it into the respective FPGA, there is a simple design flow(Figure 6).
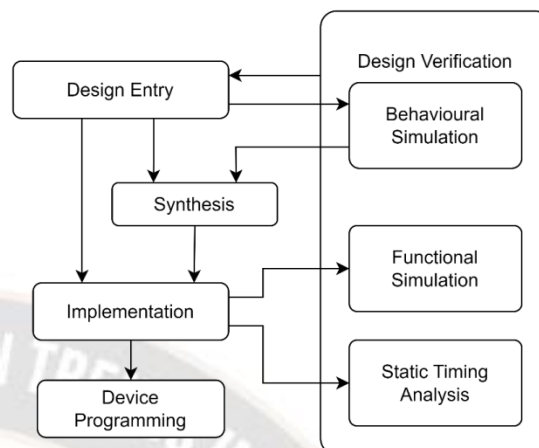

Figure 6. FPGA Design Flow

We did the RTL analysis which is the first step of programming the FPGA and obtained the logical schematic and further are synthesis and the implementation steps, which are the essential steps to program the board. Failing at any step will not let us move to the next step. The final step is the Bitstream generation which converts all the code into a stream of bits as its name exactly states. Then the board is connected to the computer and after the software detects the hardware (FPGA) successfully, the board is programmed with the code which we give as the input. It should be noted that any change in the code at any step after the RTL analysis, the procedure should be done again all over from the RTL analysis step. In addition to this, we can also get the usage details of the available resources on the board and also the respective design layout. At first, the input is taken from the onboard switches and LEDs to check if the logic was successfully implemented. After checking so, the physical components such as the sensors and the external LEDs are connected
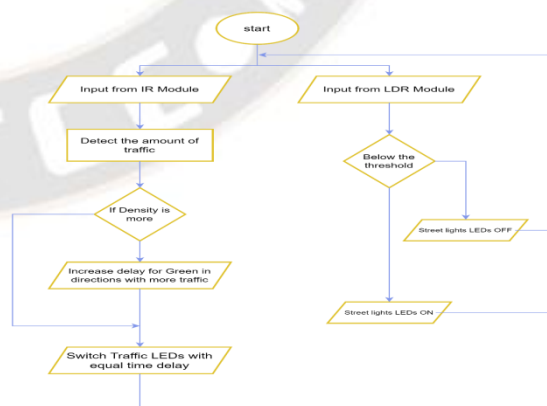
IV.   FLOW CHART

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Figure 7. Flow char of the operation of the system

3114

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TABLE 1. Usage details of board resources

Resource	Available	Utilization	Utilization %
LUT	20800	249	1.20
FF	41600	39	0.09
IO	170	21	12.35
BUFG	32	1	3.13

V. RESULTS AND DISCUSSION

The simulation results shows some of the conditions of traffic and how the LEDs switch between states depending on the input. From Figure 4.3, it can be seen that when the density is more, the switching is prioritized to the more densed direction and next to the remaining and the glow time is increased for the green light in that direction.
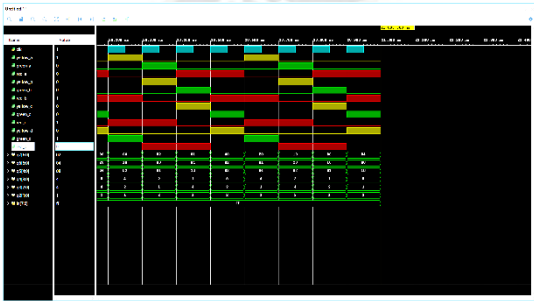

Figure 4.1: Equal traffic in all directions (A, B, C & D)
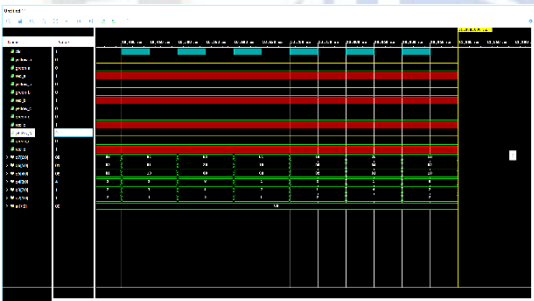

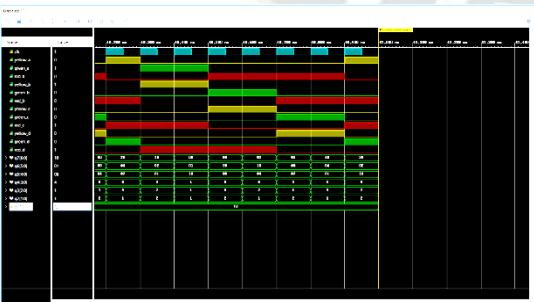Figure 4.2: No traffic in any direction

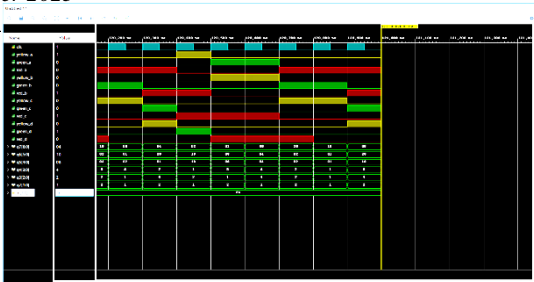Figure 4.3: More traffic in 3 directions and less in rest.

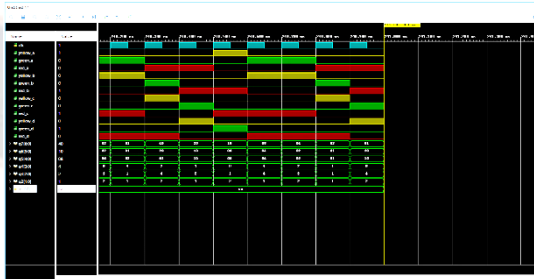Figure 4.4: More traffic in 2 directions and in the rest.

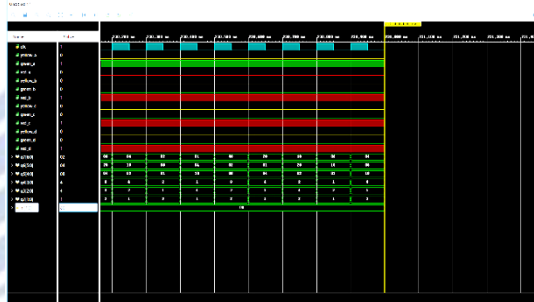Figure 4.5: More traffic in 1 direction and less in rest

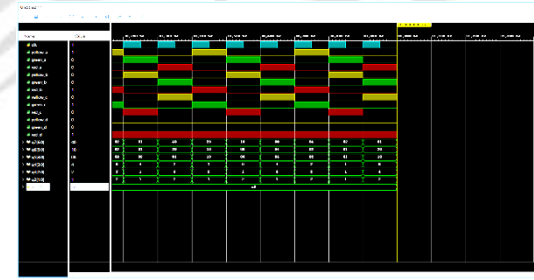Figure 4.6: Equal traffic in 3 directions and none in the rest

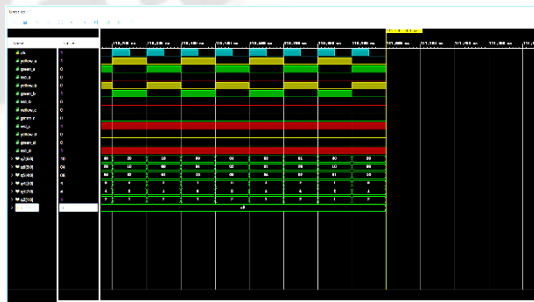Figure 4.7: Equal traffic in 2 directions and none in rest

Figure 4.8: Traffic in only 1 direction and none in rest

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VI. CONCLUSION

With this system, we were able to implement an automatic Traffic Control System and an automatic Street Light System with the use of EDGE Artix 7 FPGA, The sensors namely IR(Infra Red) and LDR (Light Dependant Resistor) were successfully interfaced and made to work to switch the traffic signals and the street lights respectively. The system was able to detect the amount of traffic and increase the delay of the lights in that respective direction. Similarly, it was able to detect the ambient light and when it got dark i.e., when the light intensity in the surroundings began to go below the given threshold, the system got to switch on the street lights.

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3116