FPGA-Based Advanced Traffic Light Controller Simulation

Parasmani, Shri Gopal Modani

Abstract— Present Traffic Light Controller (TLC) is based on microcontroller and microprocessor. These TLC have limitations because it uses the pre-defined hardware, which is functioning according to the program that does not have the flexibility of modification on real time basis. Due to the fixed time intervals of green, orange and red signals the waiting time is more and car uses more fuel. FPGA has many advantages over microcontroller, some of these advantages are; the speed, number of input/output ports and performance which are all very important in TLC design, at the same time ASIC design is more expensive than FPGA. Most of the TLCs implemented on FPGA are simple ones that have been implemented as examples of FSM. This paper concerned with an FPGA design implementation of a low cost 24-hour advanced traffic light controller system that was built as a project of a VLSI design subject using VHDL.

Index Terms— FPGA, VHDL, VLSI, Xilinx.

1 Introduction

FAST transportation systems and rapid transit systems are nerves of economic developments for any nation. All developed nations have a well-developed transportation system with efficient traffic control on road, rail and air. Transportation of goods, industrial products, manpower and machinery are the key factors which influence the industrial development of any country. Mismanagement and traffic congestion results in long waiting times, loss of fuel and money. It is therefore utmost necessary to have a fast, economical and efficient traffic control system for national development.

The monitoring and control of city traffic is becoming a major problem in many countries. With the ever increasing number of vehicles on the road, the Traffic Monitoring Authority has to find new methods of overcoming such a problem [1-4].

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 [5]. Many system designs that used to be built in custom silicon VLSI [6] 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 [7].

In this paper the main objective was to design a 24-hour traffic light controller to manage the traffic movement of four roads at the same time, and achieve maximum utilization for the four roads. Optimal traffic light control is a multi-agent decision problem; the design learns the expected waiting times of cars for red and green lights at each intersection [4-6]. In the rush hours, when people going to work or coming back to home the traffic lights of all roads are controlled with fixed time. However, in the normal time, the main roads are controlled with a fixed time while the narrow roads are controlled autonomously by sensors [8-10].

2 State Diagram

Fig.1 shows the state diagram of the controller which includes 65 states. The transition from state 0 to state 19 depends only on the time delay for each traffic state, which represents the case when all sensors are active; this means that there are cars in all roads. States (s0, s4, s8, s12, and s16) are the main states in which the traffic is either green or red. There are three intermediate states between each two of the main states, these intermediate states represents the Yellow of the active traffic (Green), all red which is the safety state, and Red-Yellow for the next active traffic. When all sensors are active the transition of the main states will follow the sequence of the green light.

3 Field Survey & Industrial Visit

3.1 Survey at Punjab

Traffic light system in Punjab is microcontroller based. Traffic flow is controlled manually i.e. surveillance based. The timers are user operated i.e. during busy hours the transition time for red and green signals is more as compared to the usual transition.

3.2 Industrial Visit at Jaipur: Shakti Enterprises

Traffic Light controller is based on the concept of:

1. Microcontroller through RTC
2. Microprocessor with GPS

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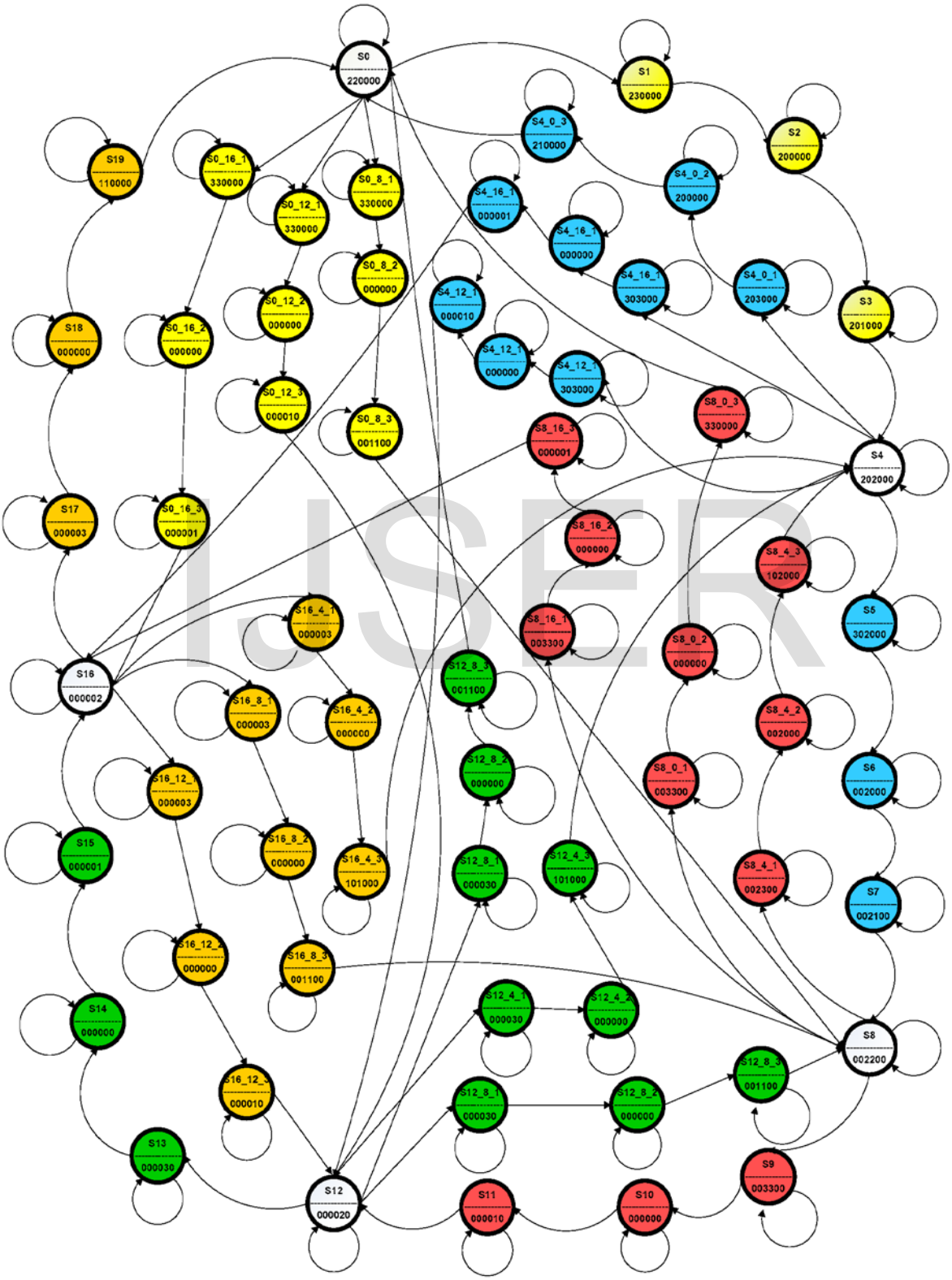
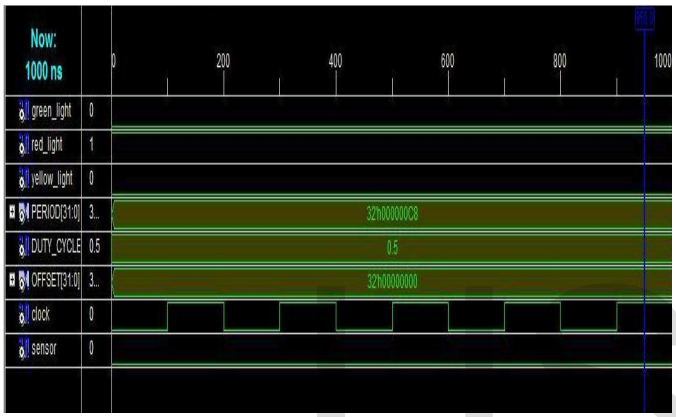
Fig. 1 State Diagram of the Controller



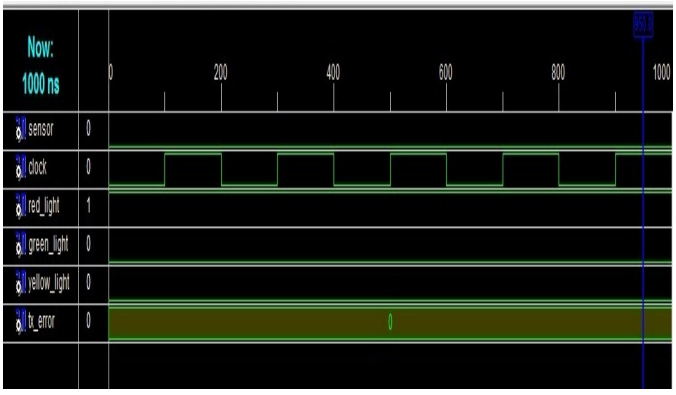
4 Software Implementation

The Xilinx FPGA Spartan3e series has redefined programmable logic by expanding the traditional capabilities of field programmable gate arrays (FPGAs) with new levels of integration and features that address high performance system design issues. In a single, off-the-shelf programmable Xilinx device, systems architects can take advantage of microprocessors, the highest density of on-chip memory, multi-gigabit serial transceivers, digital clock managers, on-chip termination and more. The result is that Xilinx FPGAs helps designers to simplify board layout, reduce bill of materials, and get products to market faster than ever before.

5 Results



(a)



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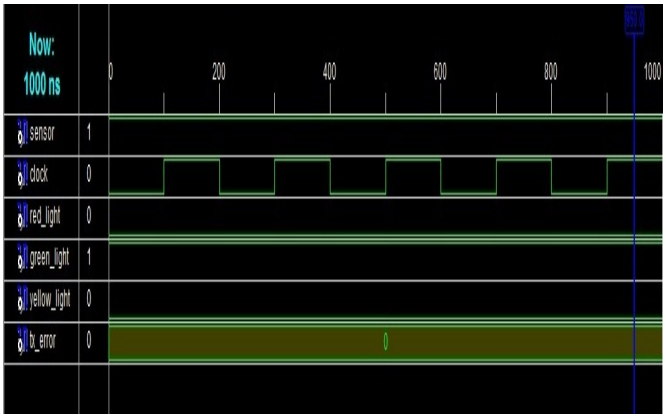

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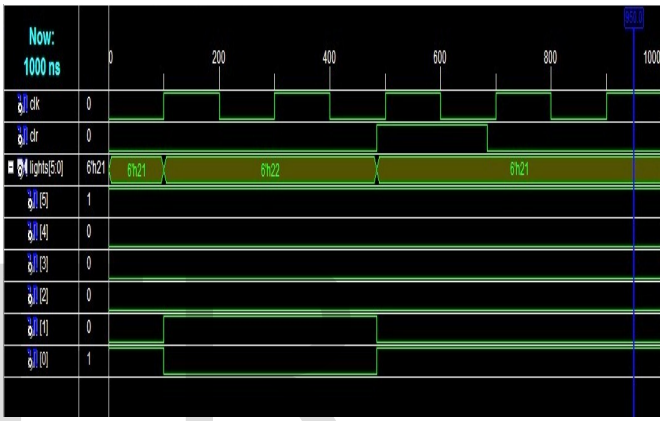

(d)

Fig.2 Simulation results of the controller

6 Conclusion

The improvement of town traffic condition is largely dependent on the modern ways of traffic management and control. Advanced traffic signal controllers and control system contribute to the improvement of the traffic problem. An FPGA design of a 24-hour traffic light controller system of a four roads structure with six traffic lights has been simulated using infrared sensor. The system has been designed using VHDL, simulated on Xilinx 9.1. Our design reaches the maximum utilization of the traffic either during rush hours or normal time. More functions could be added to the design. Some of these functions are to control more than six traffic lights. Also, to allow the user to assign the time for each traffic light, adding more sensors on each road to count the number of cars in each road and check for the longer queue to increase the timer for that road, another function is to link the traffic light with the other traffic lights along the streets to increase the flow of traffic.

Acknowledgment

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