



FPGA Based Smart Traffic Light System For Emergencies

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Abstract: The FPGA is employed to implement intelligent traffic management algorithms, ensuring swift and safe ambulance navigation through congested urban traffic. The system's architecture emphasizes adaptability, allowing for easy integration with existing healthcare and emergency response infrastructures. To notify all the other lanes about the arrival of ambulance in a particular lane, Blue LED is incorporated with existing signals. Through extensive simulations and practical testing, the proposed FPGA-based Smart Traffic Light System demonstrates significant improvements in emergency response times and patient outcomes in metro city scenarios, providing a promising solution for addressing the unique challenges posed by urban environments. This research contributes to the growing field of smart healthcare technologies and lays the foundation for the implementation of FPGA-driven innovations in emergency medical services tailored for metropolitan cities.

Index Terms - FPGA, Medical, Technology, MOD-100, MOD-120, MOD-3, Elaborated Design, Mapped Schematic

I. INTRODUCTION

In the fast-paced world of modern urban living, ensuring timely response during emergency situations is paramount. One of the critical challenges faced by emergency services is navigating through dense traffic to reach the scene of an incident swiftly. Traditional traffic management systems often fail to address this issue effectively, leading to delays that can prove fatal. To bridge this gap, innovative solutions utilizing cutting-edge technologies have emerged, among which FPGA-based Smart Traffic Light System stand out. This introduction delves into the transformative potential of FPGA-based Smart Ambulance and Traffic Light Systems, exploring how these systems create a seamless pathway for ambulances through congested urban traffic. By prioritizing emergency vehicles and dynamically adapting traffic signals, these systems enhance the efficiency of emergency response, ultimately saving lives and ensuring public safety. This technological advancement represents a significant stride toward a safer, more responsive urban environment, where every second counts in saving lives.

FPGA, or Field-Programmable Gate Array, technology offers unparalleled flexibility and computational power. It can be programmed and reprogrammed to perform a wide array of tasks, making it ideal for real-time applications. In the context of emergency services, particularly ambulance response, FPGA-based solutions have revolutionized the way we handle traffic management during critical moments.

These communication capabilities are further augmented by FPGA-based encryption and security protocols, ensuring the integrity and confidentiality of patient data paramount concern in modern healthcare systems. Additionally, the navigation subsystem can harness FPGA-accelerated medical devices, and external networks. Utilizing advanced protocols and FPGA-accelerated processing, this unit mapping and localization algorithms, providing paramedics with real-time situational awareness and optimal route guidance, thereby reducing response times, and enhancing patient outcomes. [1]

II. METHODOLOGY AND IMPLEMENTATION

2.1 METHODOLOGY

Power Supply Unit: The power supply unit (PSU) for the FPGA-based smart ambulance project in metropolitan cities is a critical component that demands meticulous design considerations to ensure reliable, efficient, and uninterrupted operation. Given the dynamic and demanding nature of emergency medical services (EMS), the PSU must be robust, resilient to fluctuations, and capable of delivering clean power to all subsystems, ranging from FPGA processors and communication modules to medical devices and onboard systems.

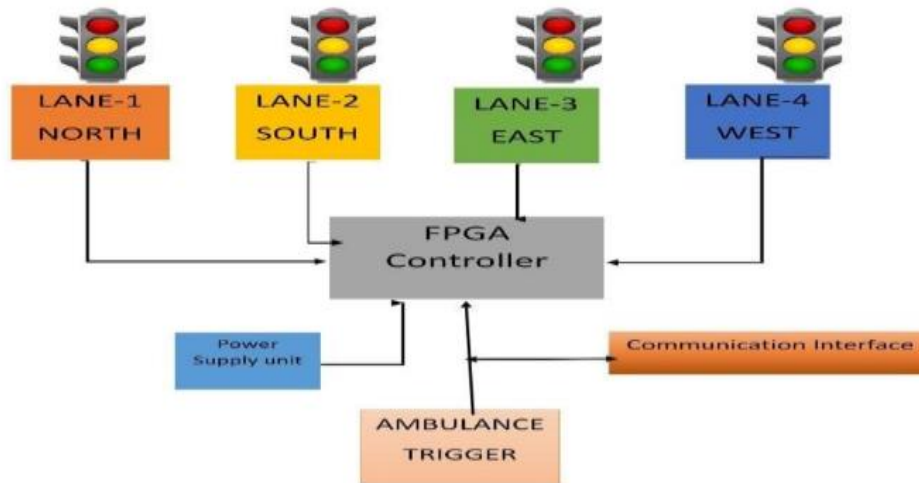


Fig.1-Pictorial Representation of Traffic Light Control.

FPGA controller Unit: In the context of the FPGA-based smart ambulance project for metropolitan cities, the FPGA controller unit serves as the central nervous system, orchestrating the seamless integration and real-time operation of various subsystems. Engineered for high-performance computing and rapid data processing, the FPGA controller unit leverages reconfigurable logic and parallel processing capabilities to execute complex algorithms—from traffic analysis and collision prediction to medical data fusion and communication protocols. By interfacing with sensors, actuators, and communication modules, the FPGA controller unit enables dynamic adaptability, ensuring optimal vehicle control, medical monitoring, and navigation functionalities tailored to the dynamic demands of urban emergency responses.

Communication Interface: The communication interface unit for the FPGA-based smart ambulance system facilitates seamless data exchange between onboard subsystems, ensures high-speed, secure, and reliable communication, enabling real-time coordination, telemedicine consultations, and dynamic routing optimization for enhanced emergency response in metropolitan environments.

Ambulance Trigger: The Ambulance Trigger Unit serves as the pivotal interface in the FPGA-based smart ambulance system. Designed to detect emergencies, it rapidly initiates vehicle control, medical monitoring, and communication subsystems. Utilizing real-time data analytics, the trigger unit ensures swift responses, optimizing patient care and navigation in bustling metropolitan environments. Once the ambulance is detected, it communicates with the traffic light controller. This can be done via wireless communication.

Traffic Light: In the FPGA-based smart ambulance project for metro cities, an essential component is a dynamic traffic light signal unit. This unit employs real-time algorithms to prioritize ambulance movement, ensuring minimal delays by dynamically adjusting traffic signals based on the ambulance's proximity and urgency, thereby optimizing emergency response times and enhancing overall system efficiency.

2.2 IMPLEMENTATION

The system with electronic hardware that powers the code and has distinct modulus counters for the various time counts on each lane is explored using a block diagram method as represented in **Figure 2**. The traffic signal changing is handled by the emergency block. There are numerous instances.

Case 1: In the event of an emergency, such as an ambulance arriving in any one of the lanes, the red traffic light of that lane automatically changes to green, and by turning on the blue light indicating the arrival of the ambulance.

Case 2: If four ambulances are encountered at four different lanes simultaneously, each lane's signal will turn green. However, if all lanes turn green at the same time, this could cause collisions and congestion. Therefore, the idea is to sense the distance between ambulances and adjust the lanes' green signal time based on which ambulance is closest wireless technology-incorporated communication device. Assume that if the ambulance in lane 1 is closer to the sensing or communication device than the other lanes, the lane is switched to green until the ambulance leaves. At that point, the next closest ambulance in the other lanes is modified to pass through using the same method earlier than the other lanes.

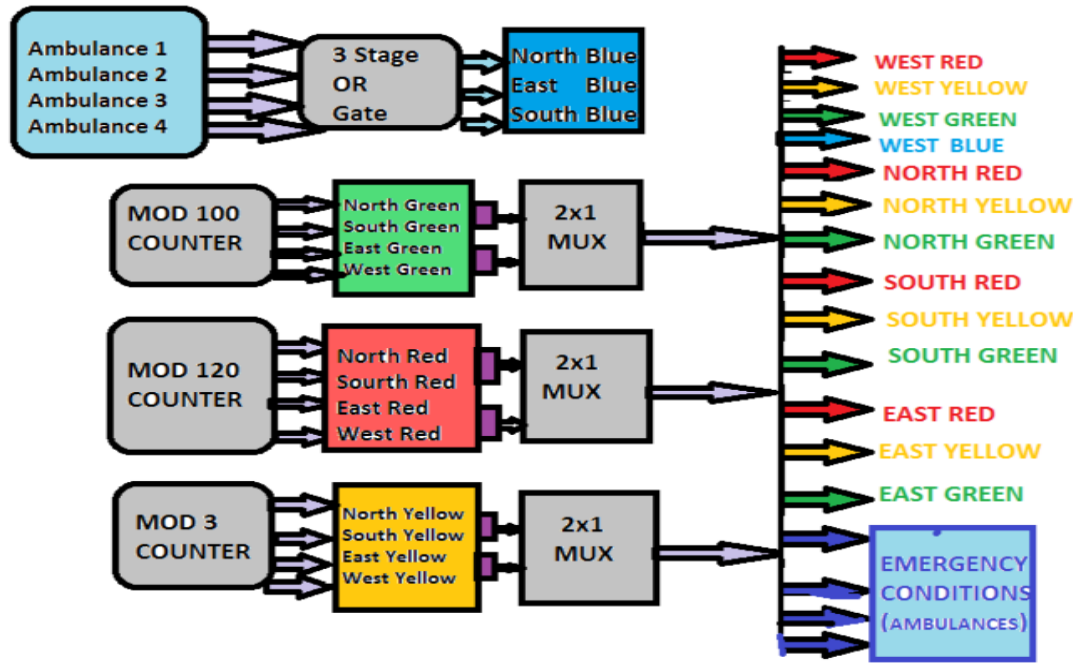


Fig.2: Block diagram Representation of the Four-way Traffic light controller

MOD -100 Counter: The MOD 100 counter is associated with the green signal to be continuously ON for 100 counts for the vehicle to be pass on in normal scenario rather than emergency scenarios in all the four lanes.

MOD- 120 Counter: The MOD 120 counter is associated with the red signal to be continuously ON for 120 counts for the vehicles to stop on in normal scenario rather than emergency scenarios in all the four lanes.

MOD-3 Counter: The MOD 3 counter is associated with the yellow signal to be continuously ON for 3 counts for the vehicles to get ready to move on in normal scenario rather than emergency scenarios in all the four lanes.

III. RESULTS AND DISCUSSION

As discussed above the system works for all four lanes efficiently by dynamically altering the traffic signal and by navigating the ambulance. The system is simulated and verified the working for all four lanes using the simulation tools Xilinx Vivado and Cadence.

We have also implemented the functionality of the system deducing it to two-way lanes namely north and east by configuring and programming the FPGA board. Similarly, the system holds good for other two lanes.

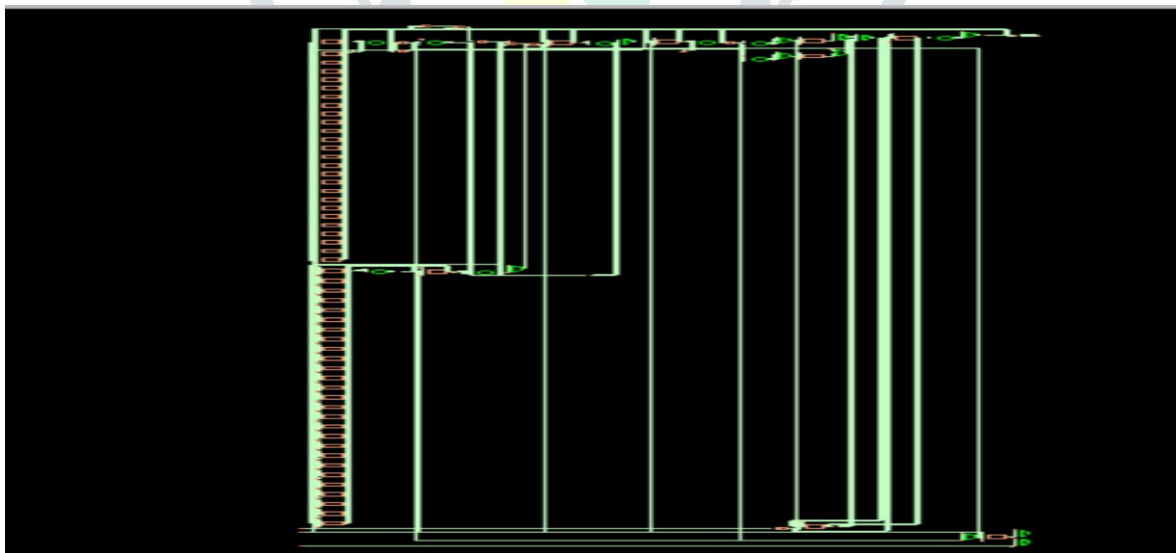


Fig.3 unmapped Schematic in Cadence tool

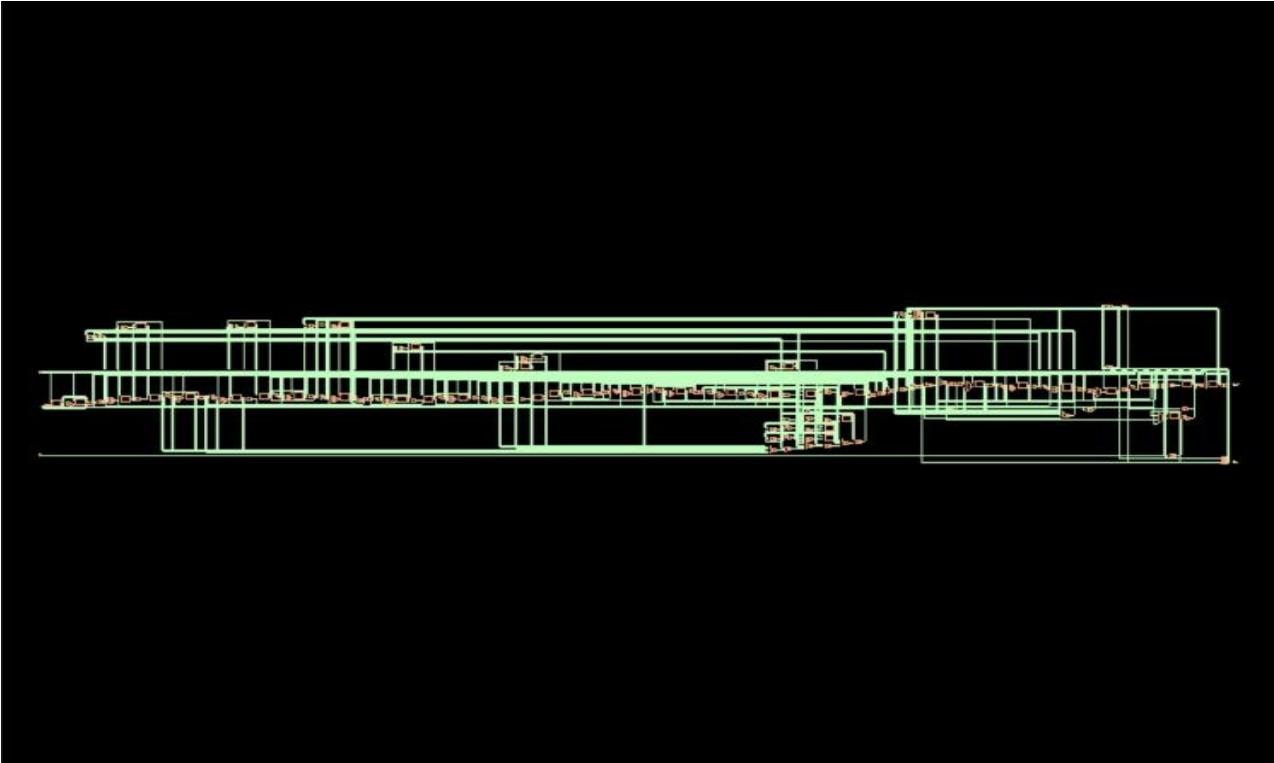


Fig.4 Mapped Schematic in Cadence tool

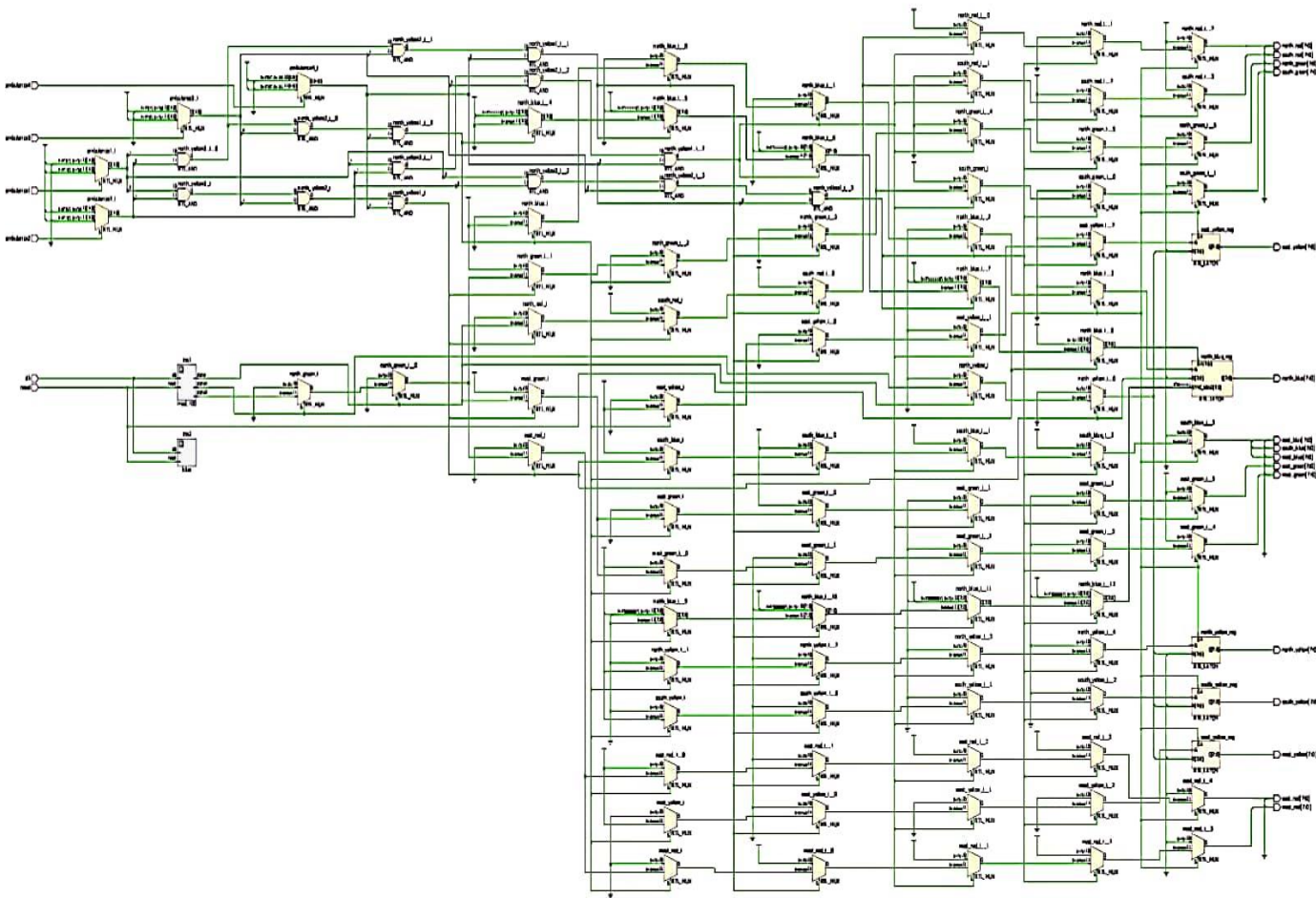


Fig.5 Elaborated Design for Four -way in Vivado tool

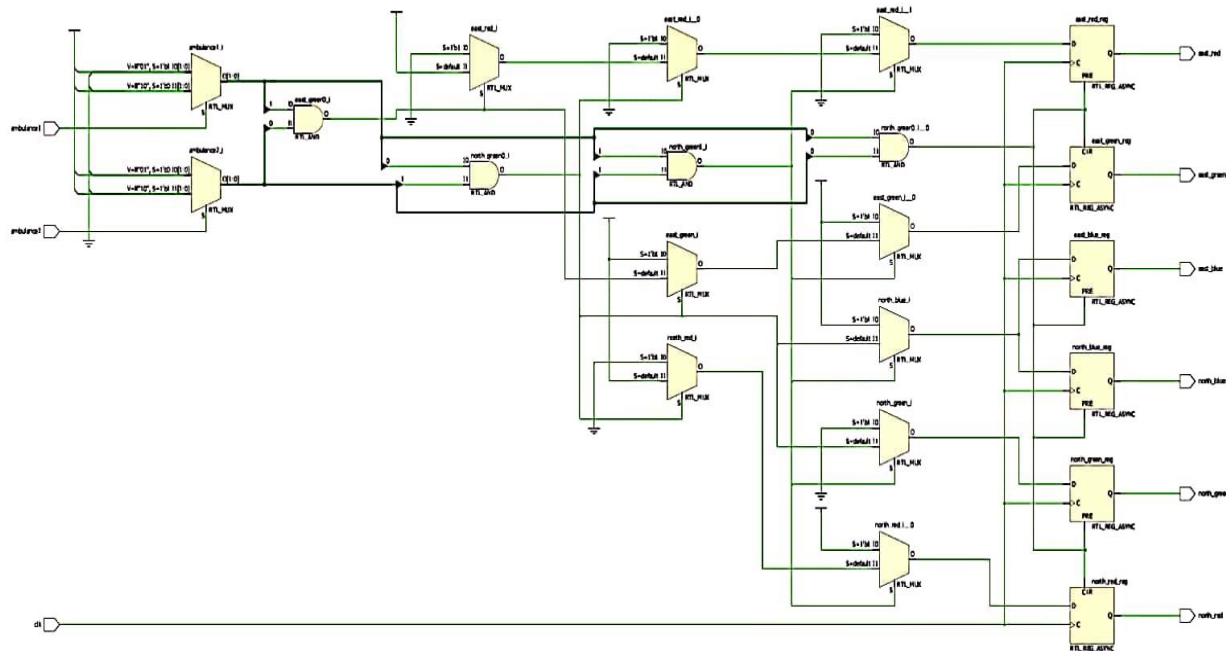


Fig.6 Elaborated Design for Two -way in Vivado tool

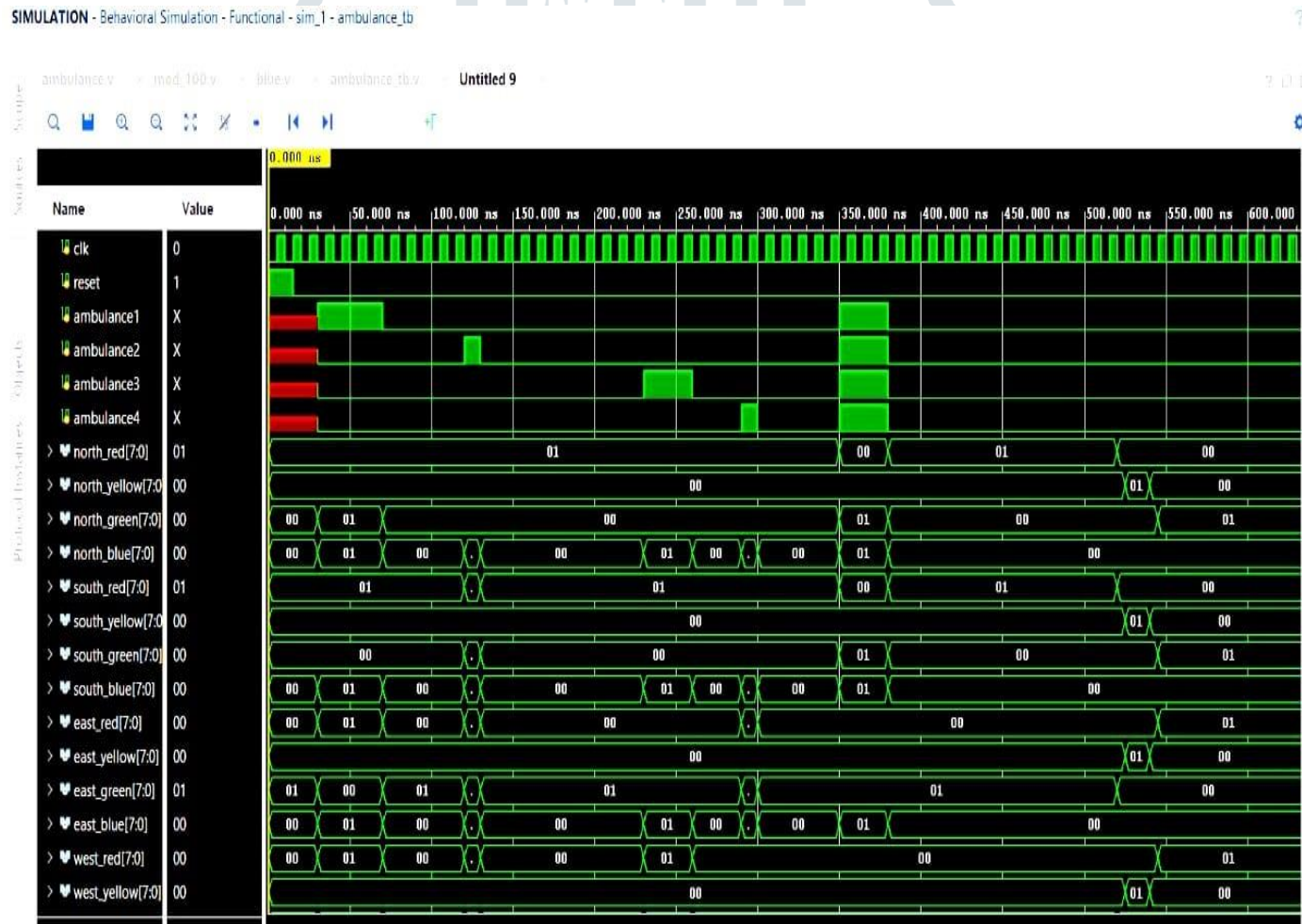


Fig.7 Simulation Results of Four way with arrival of Ambulance in Vivado tool

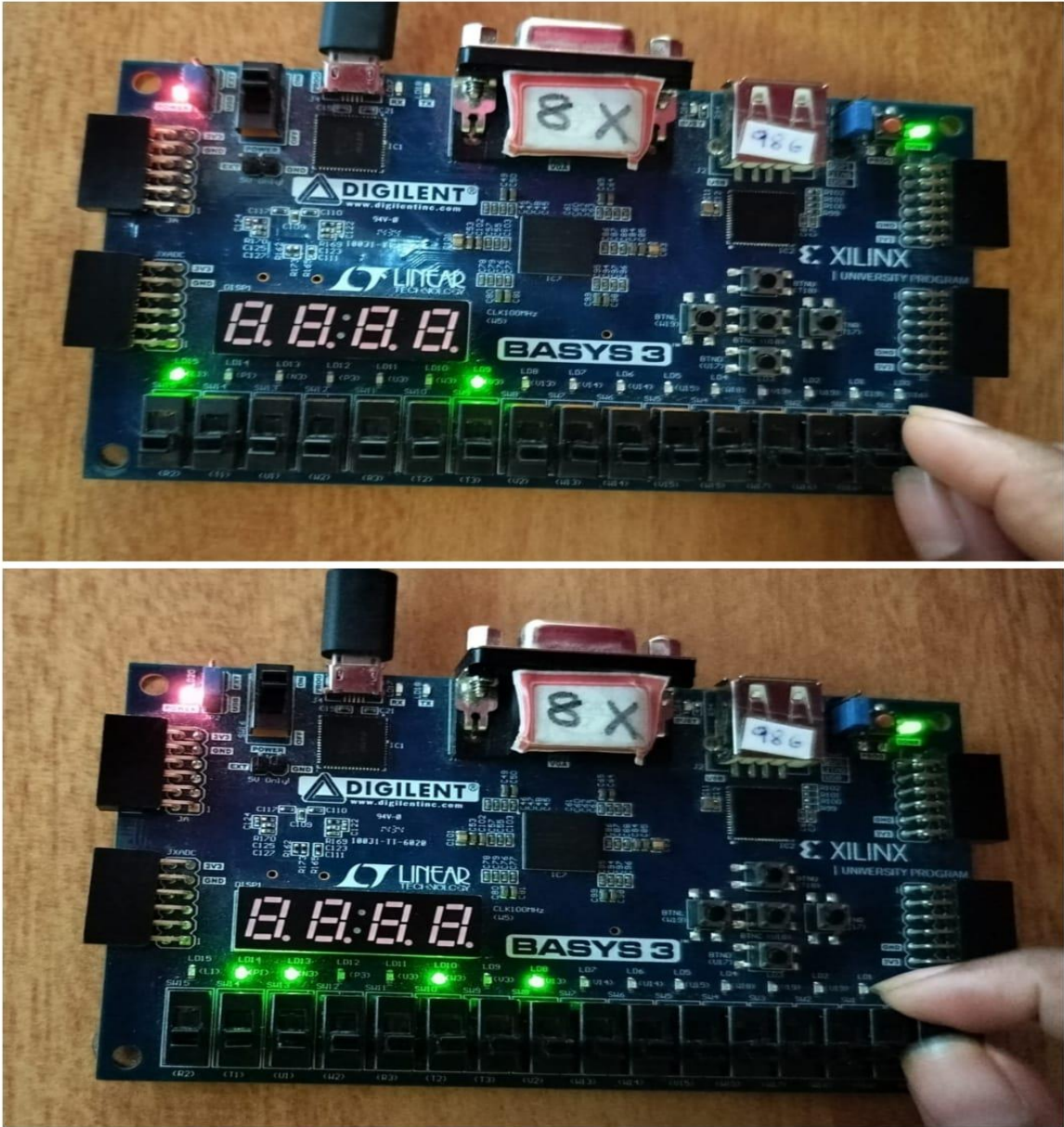


Fig.8 Hardware implementation on BASYS3 FPGA

Area Report

Generated by: Genus(TM) Synthesis Solution 20.11-s111_1
Generated on: jan 8 2024 07:16:08 pm
Module: traffilight
Technology library: slow_vdd1v0 1.0
Operating conditions: PVT_0P9V_125C (balanced_tree)
Wireload mode: enclosed
Area mode: timing library

Instance	Module	Cell Count	Cell Area	Net Area	Total Area	Wireload
traffilight		155	426.816	0.000	426.816	<none> (D)

(D) = wireload is default in technology library

Fig.9 Area Report generated in Cadence

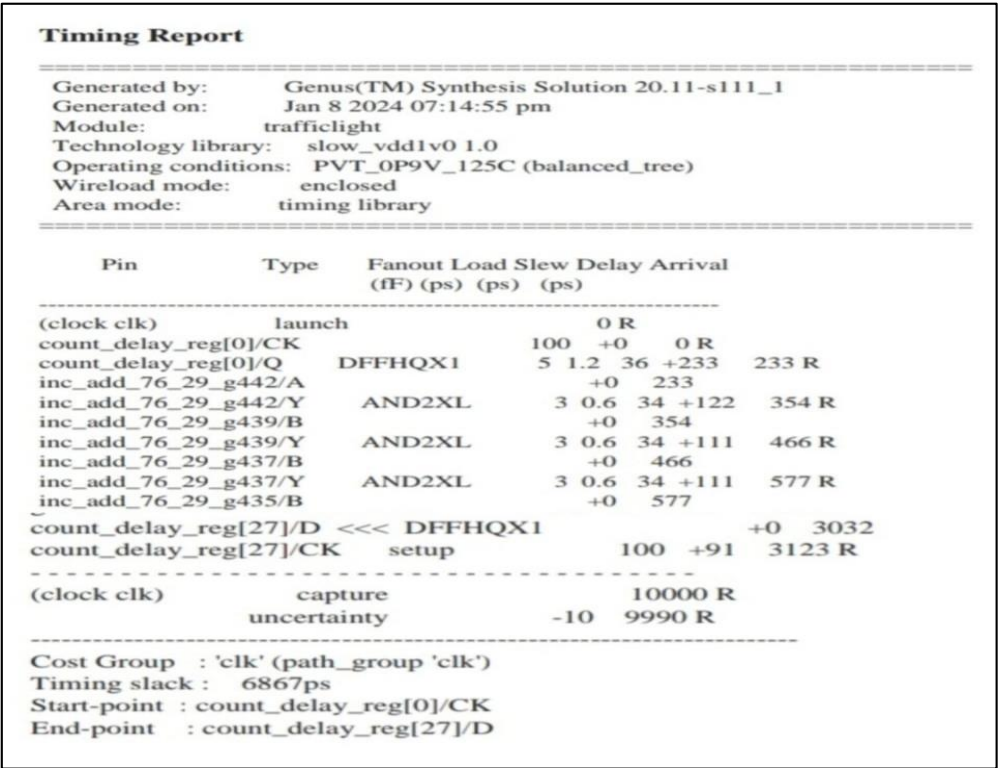


Fig.10 Timing Report generated in Cadence

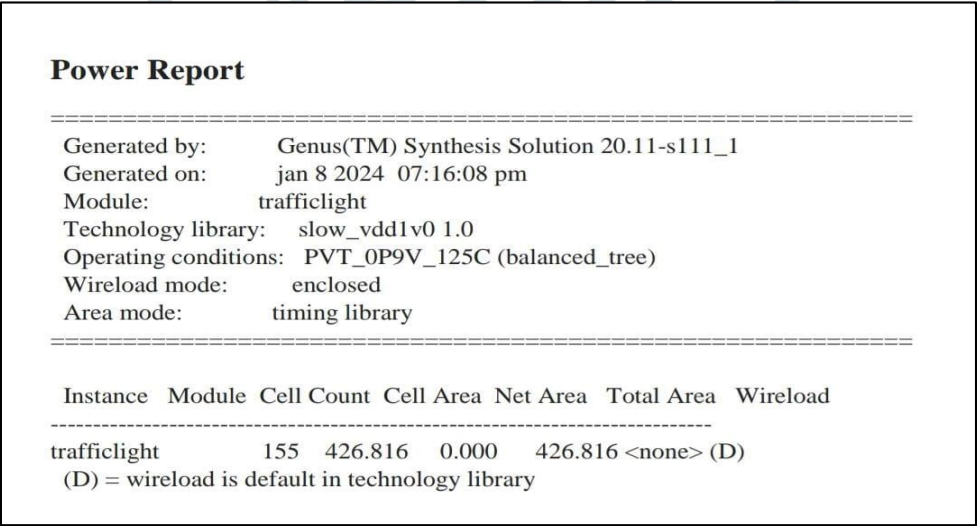


Fig.11 Power Report generated in Cadence

IV. CONCLUSION

The FPGA-Based Ambulance-Triggered Traffic Light System represents a significant leap forward in urban emergency response and traffic management. By seamlessly intelligent FPGA processing, dynamic traffic signal control, inter-intersection communication, and public awareness initiatives, the system addresses the critical challenge of delayed ambulance response times in congested urban environments. In conclusion we are able to successfully implement the FPGA based smart ambulance for metro cities in which dynamically modifies the traffic signal using FPGA which is programmed using Verilog RTL and analyzed its performance by simulating the code through the simulation tools like Cadence and Vivado. For interfacing the Hardware and software we have used Vivado tool through which we integrated the functioning of hardware successfully, also we have estimated the performance parameters like area, timing, power which plays crucial role in field of FPGA.

V. FUTURE WORK

Future developments for 4-way traffic signal systems with ambulance detection are anticipated to bring about major improvements in urban traffic management responsiveness, efficiency, and safety. In the current project, we have developed an algorithm that detects the presence of an ambulance and adjusts traffic signals to allow the vehicle to pass. This allows the ambulance to communicate with the FPGA board, facilitating the management of traffic in metro areas.

The primary goal of the project was to save lives by allowing the ambulance to navigate the heavy traffic in today's metropolitan cities. To this end, we designed the signal so that it would react when an ambulance appeared in any of the four lanes simultaneously or at different times. By adding other wireless communication systems, we can further expand ambulance's intelligence and increase the system's effectiveness for the benefit of society.[10][13]

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