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FPGA Implementation of a Bus Ticketing System using Verilog HDL

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ABSTRACT

The Verilog-based automatic bus ticketing system enhances public transportation by automating fare collection, reducing human intervention, and improving passenger convenience. Implemented on an FPGA platform, the system integrates key modules for passenger authentication, fare calculation, and transaction logging. A smart card reader ensures seamless validation, while a digital display provides real-time fare updates. Simulation results demonstrate efficiency in handling multiple passengers with high accuracy. The FPGA-based approach offers scalability, security, and potential IOT integration, positioning it as a reliable solution for modern urban transit systems.

Keywords: Verilog HDL, Ticket selection, Coin Calculation, Quartus II

I. INTRODUCTION

Public transportation is essential for urban mobility, and efficient fare collection systems play a key role in ensuring smooth operations. Traditional ticketing methods often suffer from inefficiencies such as long queues, revenue leakage, and human errors. Automated ticketing systems address these issues by leveraging modern computing and hardware design methodologies.

PNBS: A Hub of Connectivity PNBS is a core component of the Andhra Pradesh State Road Transport Corporation (APSRTC) network. Handling thousands of buses daily, it features well-structured platforms, waiting lounges, ticketing counters, and advanced passenger amenities. Given its significance, PNBS is an ideal location for implementing automated fare collection solutions to optimize passenger flow and operational efficiency.

Automated Ticketing Systems in Urban Transport Automated ticketing systems have revolutionized urban transport networks by ensuring efficient fare collection, reducing fraud, and enhancing passenger convenience. As cities continue to grow, the adoption of AFC systems is becoming increasingly important to maintain reliable and scalable public transportation solutions.

The Impact of AFC Systems on Road Transport AFC systems play a pivotal role in modernizing public transportation by minimizing manual intervention and ensuring accurate fare transactions. The evolution of AFC technology is closely linked with advancements in road transport infrastructure, allowing seamless integration and improved service quality.

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Integration of Computer Networks and Automated Control Modern AFC systems integrate computer networks with automated control mechanisms to facilitate smooth transactions. Advances in integrated circuit technology, particularly programmable logic gate (PLG) circuits, have significantly improved the efficiency and reliability of these systems, enabling real-time data processing for an enhanced passenger experience.

Verilog Programming in Automated Ticketing Systems The Verilog programming language is instrumental in designing automated ticketing solutions. Its flexibility, hardware description capabilities, and precise timing control make it an ideal choice for developing digital circuits used in AFC systems. By leveraging Verilog, engineers can create efficient and scalable fare collection mechanisms that cater to the growing demands of urban transport.

Enhancing System Efficiency through Verilog Verilog's robust features allow for the optimization of AFC systems, supporting the design of high-performance, real-time processing ticketing machines. Its ability to describe complex digital circuits ensures accuracy and efficiency, making it the foundational programming language for bus fare collection technologies.

II. EXISTING METHOD

Efficient ticketing systems are essential for smooth bus transit. Traditional paper tickets have been largely replaced by digital and automated solutions to enhance efficiency, reduce fraud, and improve user experience. This review analyzes existing bus ticketing technologies, their benefits, limitations, and evolving trends, while also exploring potential future advancements.

Paper Ticketing: A long-standing fare collection method where passengers purchased pre-printed tickets from conductors or kiosks. While simple and widely accessible, they were prone to inefficiencies, fraud, and counterfeiting.

Token System: Reusable metal or plastic tokens were used for fare payment, reducing fare evasion and transaction delays by eliminating cash handling. While simple and effective, they had drawbacks such as production costs, limited scalability, and the inconvenience of pre-purchasing. Though largely replaced by digital systems, some areas still use them.

Magnetic Stripe Card: Introduced in the late 20th century, these cards stored fare data on a magnetic stripe, allowing passengers to swipe them for automated fare collection. They improved security and reduced cash transactions but still required physical handling and maintenance.

III. PROPOSED METHOD

This document proposes an automated bus ticketing system designed for busy hubs using Verilog HDL and Quartus II software. It aims to improve efficiency, security, and passenger experience by reducing human involvement and leveraging digital transactions. The system ensures fast data processing, low latency, and seamless integration with modern transport networks.

Ticket Selection Module :

Inputs: Route selection buttons, quantity buttons, clock signal (CLK) for synchronization, and reset signal (RST) for initialization.

Outputs: Binary codes representing the selected route (PATH) and ticket quantity (QUA).

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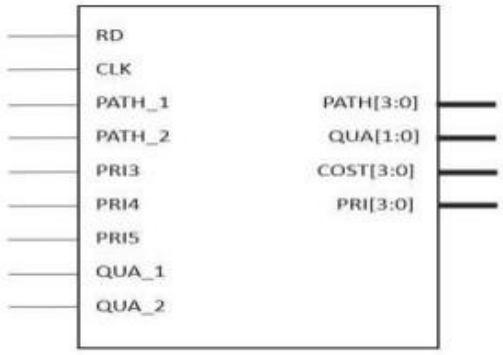


Fig 1: Ticket Selection Module

Rupees Calculation Module:

The Rupees Calculation Module determines the total fare for selected tickets based on predefined fare data.

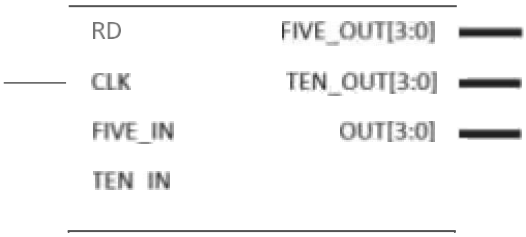


Fig 2: Rupees Calculation Module

Inputs:

Selected Route Code (PATH): Provided by the Ticket Selection Module.

Ticket Quantity (QUA): Number of tickets, also received from the Ticket Selection Module.

Fare Database: A stored mapping of routes and quantities to their respective fares.

Output:

Total Fare (COST): A binary value representing the calculated total fare.

Return Processing Module :

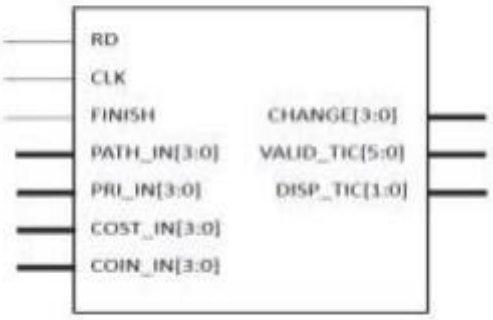
Input Process: The system resets when the RD button is pressed by a passenger.

CLK signal synchronizes operations.

Passenger presses **FINISH** after inserting a coin.

The module determines ticket issuance based on **PATH_IN** and ticket type via **PRI_IN**.

Payment details: **COST_IN** (ticket price) and **COIN_IN** (amount inserted).



Output Process:

CHANGE output updates the display module with the amount to return.

VALID_ TIC[5:0] controls six LEDs, each indicating a ticket type.

DISP_TIC regulates LED status:

LED ON → Change is given.

LED OFF → No change required.

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Display Interface Module:

The Display Interface Module presents essential ticketing information, including the selected path, ticket price, quantity, total cost, and change amount.

Components:

Module 6 (Counter):

A 3-bit binary counter (counts from 000 to 101).

Exceeding 101 triggers a carry signal and resets to zero.

Selects one of six data inputs for output.

Selector: Scans the Module 6 counter and determines which data is displayed.

Decoder : Converts 4-bit binary input into a 7-bit output for the seven-segment nixie tube display to show numbers.

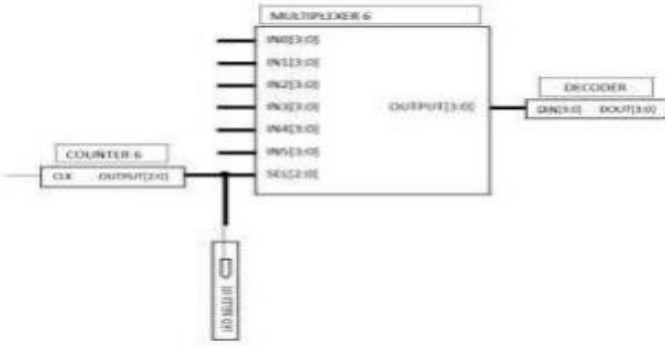

Fig 4 : Display Interface Module

Advantages :

Automation & Accuracy – Minimizes manual errors in ticketing and fare calculation.

Faster Processing – Ensures quick ticket issuance and change calculation.

Cost-Effective – Eliminates the need for cashiers or ticket collectors.

Smart Integration – Supports RFID, QR codes, and smart card payments.

Real-Time Display – Updates routes, ticket costs, and change instantly.

Applications :

Public Transportation Systems – Buses, metro trains, trams, and ferries.

Automated Toll Collection – Can be extended for highway toll collection.

Smart Ticketing Kiosks – Self-service machines at bus stations.

Parking Systems – For ticket issuance in parking lots.

Theme Parks & Events – Automatic entry ticketing for amusement parks, concerts, and sports events.

Graph: 1 Graph for power consumption of Proposed Manual VS Verilog Based Ticketing System

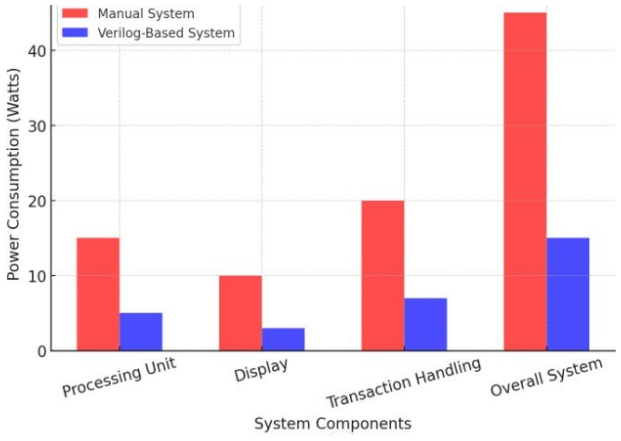

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Table: 1 Table of Comparison Parameters for Verilog-Based Automatic Bus Ticketing System

Parameter	Manual Ticketing System	Verilog-Based Automatic Ticketing System
Processing Speed	Slow – Human-dependent	Fast – Digital logic-based processing
Error Rate	High – Prone to human errors	Low – Automated fare and change calculation
Cost Efficiency	Requires staff for operation	Eliminates cashier/ticket collector costs
Automation	No automation	Fully automated ticket issuance process
Scalability	Limited to human capacity	Easily scalable with additional logic components
Integration	Manual fare input, no smart payment support	Can integrate **RFID, QR codes, Smart Cards**
Security	Prone to fraud and miscalculations	Secure transactions with digital verification
Real-Time Updates	Requires manual input	Display updates ticket, fare, and change instantly
Maintenance	Requires physical record-keeping	Low maintenance with digital storage

IV. RESULTS AND DISCUSSION

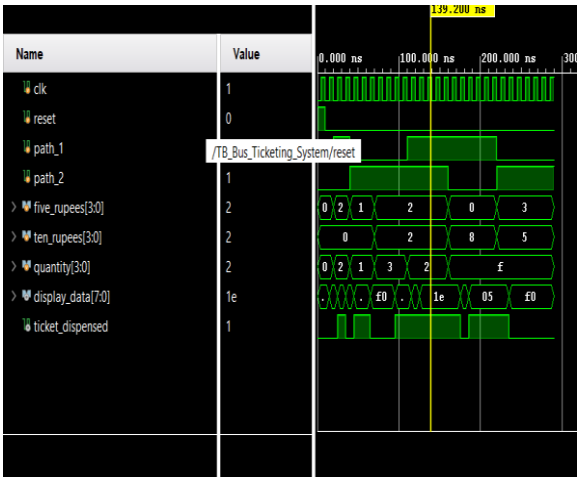

Fig 5 : Simulated Waveform

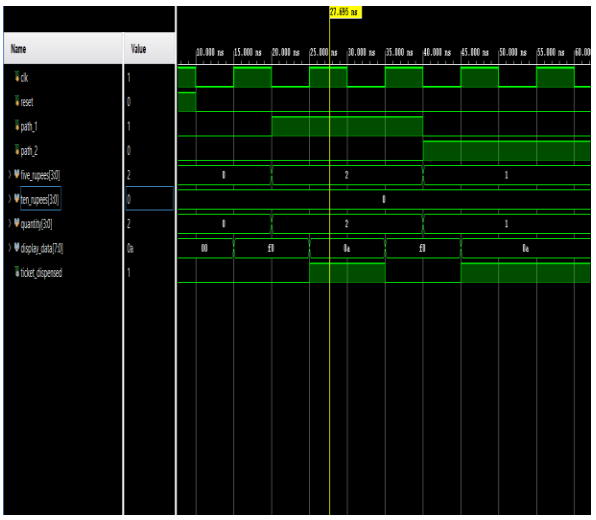

Fig 6 : Simulated Waveform

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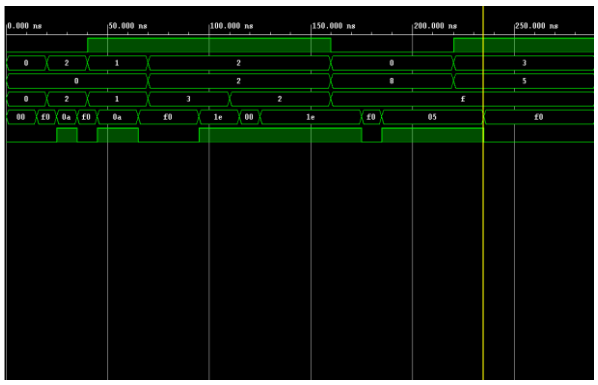

Fig 7: Simulated Waveform

V. CONCLUSION

This project presents an automated bus ticketing system designed using Verilog HDL and implemented on the Quartus II 13.1 (64-bit) platform. The system streamlines the ticket purchasing process, including path selection, display, payment processing, change dispensing, and ticket printing. As part of a graduation comprehensive training, it provides insights into real-world bus ticket vending scenarios, highlighting challenges faced by individuals unable to conduct online transactions due to factors like device issues or network limitations.

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