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A MODULAR DESIGN APPROACH FOR THE IMPLEMENTATION OF GENERAL PURPOSE VENDING MACHINE USING A HARDWARE DESCRIPTION LANGUAGE

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Abstract: This project explores a modular design approach for creating a versatile vending machine capable of dispensing various products. The proposed system leverages a hardware description language (HDL), specifically Verilog HDL, for control and implementation. This discusses the applied architecture, control algorithms, and successful module implementations. Vending machines play a crucial role in modern society, offering convenient access to snacks, beverages, and other items. Traditionally, users make selections by pressing physical or capacitive buttons. However, recent advancements have expanded vending machine capabilities to include electronic products, digital cameras, and iPods. Our project aims to enhance the practical implementation of such machines by adopting a modular design methodology and utilizing HDL for efficient control and management .By employing this approach, we create a flexible vending machine architecture that adapts to different product types. Whether dispensing coffee, hot drinks, snacks, or sweets, our system accommodates a wide range of offerings. Additionally, the modular design allows for easy maintenance, upgrades, and scalability.

***Keywords*- Vending Machine, Verilog, Hardware description language(HDL)**

I. INTRODUCTION

The Automatic machine operates based on electronics engineering, mechanical engineering, and electrical engineering, which is a collectively termed Mechatronics. People spend more time buying things in supermarkets as the market is crowded. Hence, it disappoints the customers and it leads to losing income to the vendors. Normally people touch the things (mostly vegetables) to identify their quality. At that time, they can be affected by infectious diseases. Low hygiene and quality of most of the things are finally needed more workers to maintain the quality. As a result, design of the vending machine is the best solution to avoid these problems. The vending machine is one of these automated machines which supply needed things to the customer. The vending machine can be categorized into product-oriented and service oriented machines . It distributes snacks, beverages, public transit tickets, telephone facility, entertainment things, and etc. As it has many benefits, such as, man power is no needed, flexibility in time, saving time, reducing labour cost, increasing profitability, and etc. Payment at vending machines is traditionally made by placing coins in a slot, but nowadays there are conversions that also use banknotes and card payments. The main advantages of vending machines can be formulated as – provide customers with the opportunity to make a free choice to purchase products at any time of day and year, low cost due to lack of staff, the machine can always be moved to another location and will continue to deliver products. The developed control through the language hardware description language Verilog HDL refers to a vending machine that offers five drinks that can be selected via buttons in the configuration one to one. The way in which the payment is made in the machine is through coins. The maximum price of a product from the machine is limited to a certain value. Some simulation results are demonstrated and discussed.

II. RELATED WORK

Several studies have explored the application of vending machine in veriolg HDL.yielding promising results.

i) Hardware Description Language: HDL is an abbreviation of Hardware Description Language. Any digital system can be represented in a REGISTER TRANSFER LEVEL (RTL) and HDLs are used to describe this RTL.Verilog is one such HDL and it is a general-purpose language –easy to learn and use. Its syntax is similar to C. The idea is to specify how the data flows between registers and how the design processes the data. To define RTL, hierarchical design concepts play a very significant role. Hierarchical design methodology facilitates the digital design flow with several levels of abstraction.Verilog HDL can utilize these levels of abstraction to produce a simplified and efficient representation of the RTL description of any digital design..

ii) Verilog in Vending Machine: The design of vending machines using Verilog, a popular hardware description language, has been explored in various research studies. Early works focused on creating simple models using finite state machines (FSMs) to handle basic operations like coin insertion and product dispensing. These initial designs laid the foundation but were limited in functionality and scalability. Subsequent studies introduced modular design approaches, where different modules managed tasks such as coin recognition, inventory control, and product selection, improving maintainability and scalability. Researchers also developed multi-product vending machines that could handle various products and prices, adding complexity but enhancing practicality. Additionally, optimization techniques such as power gating and parallel processing were investigated to improve efficiency and performance. Comparative studies highlighted the advantages and challenges of using Verilog over other HDLs like VHDL. Practical applications, including university projects and some commercial implementations, demonstrated the real-world viability of Verilog-based vending machine designs. These efforts collectively highlight the progression and potential of using Verilog for efficient and flexible vending machine systems.

III. PROPOSED METHODOLOGY

The proposed methodology for the vending machine system described involves a streamlined process consisting of user selection, payment verification, product dispensing, and change return. Users interact with the machine through intuitive interfaces, selecting desired items and making payments using cash or card. The machine then verifies the payment, dispenses the selected product, and returns change if necessary. Advanced inventory tracking systems ensure efficient management of stock levels and sales data, enhancing the overall user experience and operational efficiency.

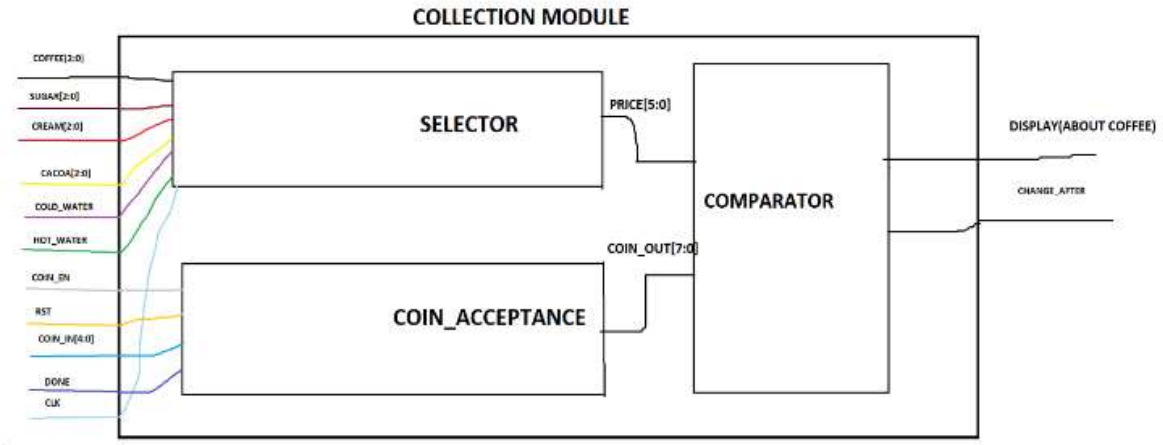

Fig 1. Block Diagram of Proposed Methodology

i) Selection: The user selects the desired item by pressing the corresponding button or using the touch screen interface on the vending machine. The user interface typically displays a range of available products, along with their prices and descriptions.

ii) Payment: After selecting the desired item, the user proceeds to make the payment. Vending machines offer multiple payment options to accommodate different user preferences. Traditional machines accept cash, allowing users to insert coins or bills into designated slots. More advanced machines are equipped with card readers, enabling users to swipe or insert credit/debit cards. Some machines even support contactless payments via NFC (Near Field Communication) for mobile payment apps like Apple Pay or Google Wallet.

iii) Verification : Once the payment method is selected and the payment is made, the vending machine verifies the payment. For cash payments, this involves checking the authenticity and value of the inserted coins or bills using coin and bill validators. For card payments, the machine processes the transaction through a secure payment gateway, ensuring that the user has sufficient funds and that the transaction is authorized. The verification process includes confirming the total amount paid and comparing it to the price of the selected item..

iv) Dispensing : Upon successful payment verification, the vending machine initiates the dispensing process. The control unit activates the dispensing mechanism associated with the selected item. This mechanism varies depending on the type of product and vending machine design but typically involves motors, actuators, or conveyors that move the product from its storage location to the collection bin or slot. The dispensing process is carefully controlled to ensure that only one item is delivered per transaction and that the item is dispensed smoothly and without damage.

v) Change: If the user has paid more than the price of the selected item, the vending machine calculates the change owed to the user. For cash transactions, the machine dispenses the change using its coin dispenser or bill return mechanism. Advanced vending machines maintain an accurate inventory of coins and bills to provide the correct change efficiently. For card transactions, any overpayment is typically refunded directly to the user's account, although this is less common in vending machines due to the precise nature of electronic payments.

vi) Inventory Tracking: Modern vending machines are equipped with sensors and software that track inventory levels and sales data in real-time. These systems monitor the quantity of each product, detect when an item is running low, and alert operators when restocking is needed. Inventory tracking systems can also provide valuable insights into sales trends, helping operators optimize product selection, pricing strategies, and machine placement. Additionally, some vending machines are connected to the internet, allowing remote monitoring and management, which enhances operational efficiency and reduces downtime.

Control Algorithm

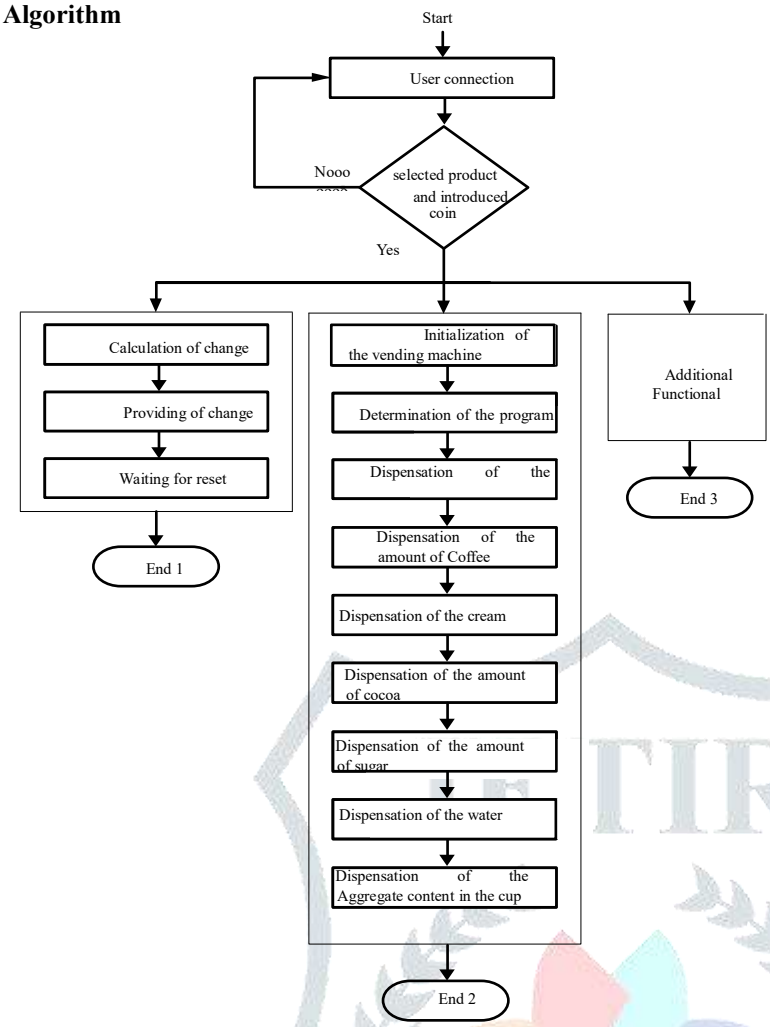

Fig 2: Control Algorithm of the proposed methodology

IV. IMPLEMENTANTION AND SIMULATION

The Item module is designed to compute the total price of selected items in a vending machine. It takes four input signals (milk, cooldrink, coffee, and tea), each of which indicates whether the corresponding item is selected (1) or not (0). Inside the module, there are four registers (milk_price, cooldrink_price, coffee_price, and tea_price) to store the prices of these items. The always block is triggered whenever there is a change in any of the inputs. Within this block, the prices for each item are set based on whether the item is selected or not, using case statements. If an item is selected, its respective price is assigned (e.g., 25 for milk, 85 for cooldrink, etc.). If not selected, the price is zero. Finally, the total price is calculated by summing up the prices of all selected items and assigned to the output price.from sklearn.model_selection import train_test_split.

The Ven_Mac module represents a vending machine's functionality. It takes inputs for item selections (milk, cooldrink, coffee, and tea) and the amount of cash inserted (cash_in). It produces outputs for the change to be returned (change_after) and a signal to indicate whether an item is dispensed (dispense_out). The module instantiates the Item module to calculate the total price of selected items (price). The always block is used to handle various conditions based on the inserted cash and total price. If the cash inserted is invalid (either zero, x, or not one of the acceptable denominations: 50, 100, 200, or 500), it displays a message and no item is dispensed, returning the inserted cash. If the inserted cash is less than the total price, it also displays a message and no item is dispensed. If the inserted cash is valid and greater than the total price, it dispenses the items, displays a message, and calculates the change to be returned by subtracting the total price from the cash inserted.

V. RESULTS AND DISCUSSION

There are some products given in the Vending Machine.Based on the rerirement of the User the user selects the desired item by pressing the corresponding button or selection on the vending machine's touch screen.The user makes the payment for the selected item, typically using cash. The vending machine will typically display the price of the item, and the user can insert the required amount of money or swipe their payment card.The vending machine verifies the payment method and amount, ensuring that the user has paid the correct amount for the selected item.Once the payment is verified, the vending machine dispenses the selected item. The item is typically delivered to a collection bin or slot at the bottom of the vending machine. If the user has paid more than the price of the selected item, the vending machine will dispense change in the form of coins or bills. Modern vending machines are often equipped with sensors and software that track inventory levels and sales data. This information can be used to restock items, adjust prices, and optimize the vending machine's performance.

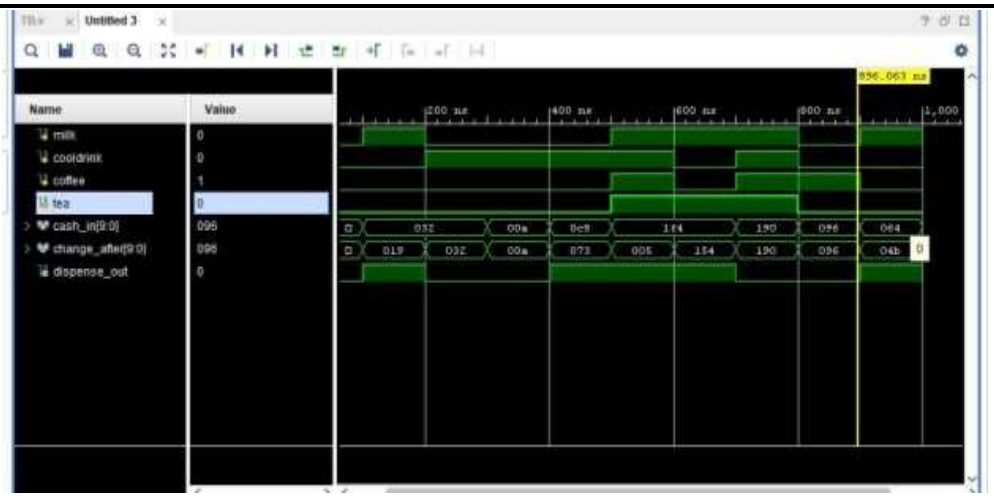

Fig 3: output window

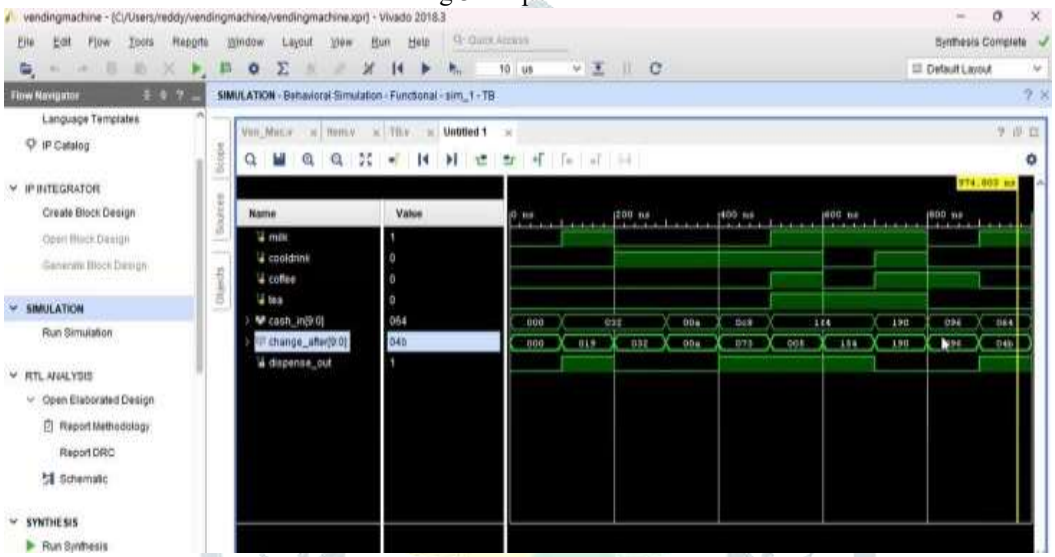

Fig 4:output window2

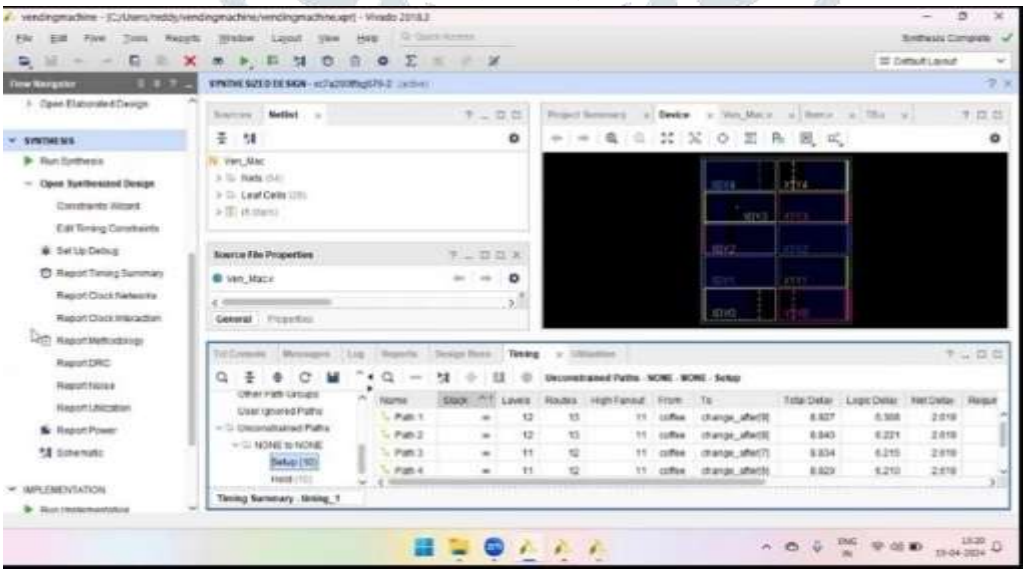

Fig 5: RTL view

Fig 6: power consumption output

VI. CONCLUSION

The vending machines will be increasingly used due to the many advantages such as low maintenance costs, offering a wide range of beverages, goods, etc. A block diagram for a type of vending machine for hot and cool drinks has been presented and discussed. On this basis the proposed architecture and the developed control algorithm are described. The control system for the studied vending machine is synthesis and implemented through the hardware description language Verilog HDL. Some simulation results of the different modules are shown and discussed. The results of the research can be applied to other types of vending machines.

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