TITLE: **Simulation and implementation of vending machine using FPGA kit using Xilinx vivado software.**

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Introduction:

- A vending machine is a self-service device that dispenses items such as snacks, beverages, and other small products to consumers automatically, typically after the insertion of currency or a credit card. These machines are widely used for their convenience, allowing customers to purchase items quickly without the need for a cashier.
- Vending machines come in various types, including snack vending machines, beverage vending machines, and combination vending machines that offer a mix of products. They are commonly found in high-traffic areas such as office buildings, schools, hospitals, airports, and shopping centers.
- The basic operation of a vending machine involves selecting a product using a keypad or touchscreen, inserting payment, and retrieving the item from a dispensing area. Modern vending machines are equipped with advanced technology, such as cashless payment systems, touchscreens, and remote monitoring. These features enhance the user experience and provide real-time data to operators, improving restocking efficiency and maintenance.
- One key advantage of vending machines is their ability to operate 24/7, offering constant availability to consumers. This makes them an attractive option for businesses looking to provide quick and easy access to products. Additionally, vending machines require minimal staffing, reducing labor costs.
- In recent years, the vending machine industry has seen significant innovation, including the introduction of healthy food options, customizable products, and even hot meals. Some machines are now equipped with AI to better predict consumer preferences and manage inventory.

Applications:

1. Healthy Food and Meal Vending
2. Pharmaceutical Vending
3. Customized Products
4. Grocery Vending
5. Vending for the Homeless
6. Art and Creative Supplies Vending

Objective:

The primary objective of vending machines is to provide a convenient, efficient, and accessible way for consumers to purchase goods and services.

Convenience: Provide 24/7 access to products, making shopping quick and easy without human interaction.

Efficiency: Streamline the purchasing process, minimizing time and effort for transactions.

Accessibility: Make products available in various locations, including remote or high-traffic areas where traditional stores may not be feasible.

Cost-Effectiveness: Reduce operational costs by eliminating the need for staff and lowering overhead expenses.

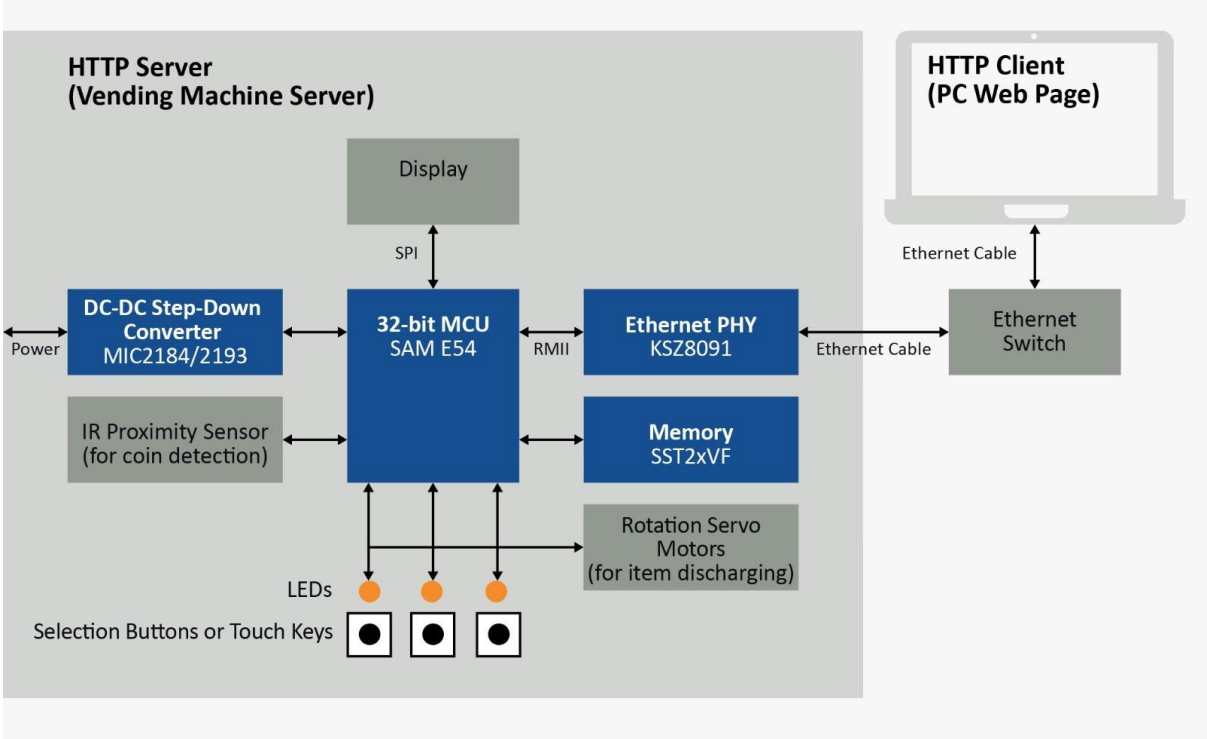
Technological Integration: Enhance user experience and operational efficiency with features like cashless payments, remote monitoring, and AI-driven inventory management.

Methodology:

Software Components

Hardware Components

Block diagram:



FPGA Implementation of Vending machine:

- Open xilinx vivado software>create New project>create File>give file name (module name)
- Select

Product category: General Purpose

Family: Artix-7

Package:csg324

Speed value: -1

Select Xc7a100tcsg324-1

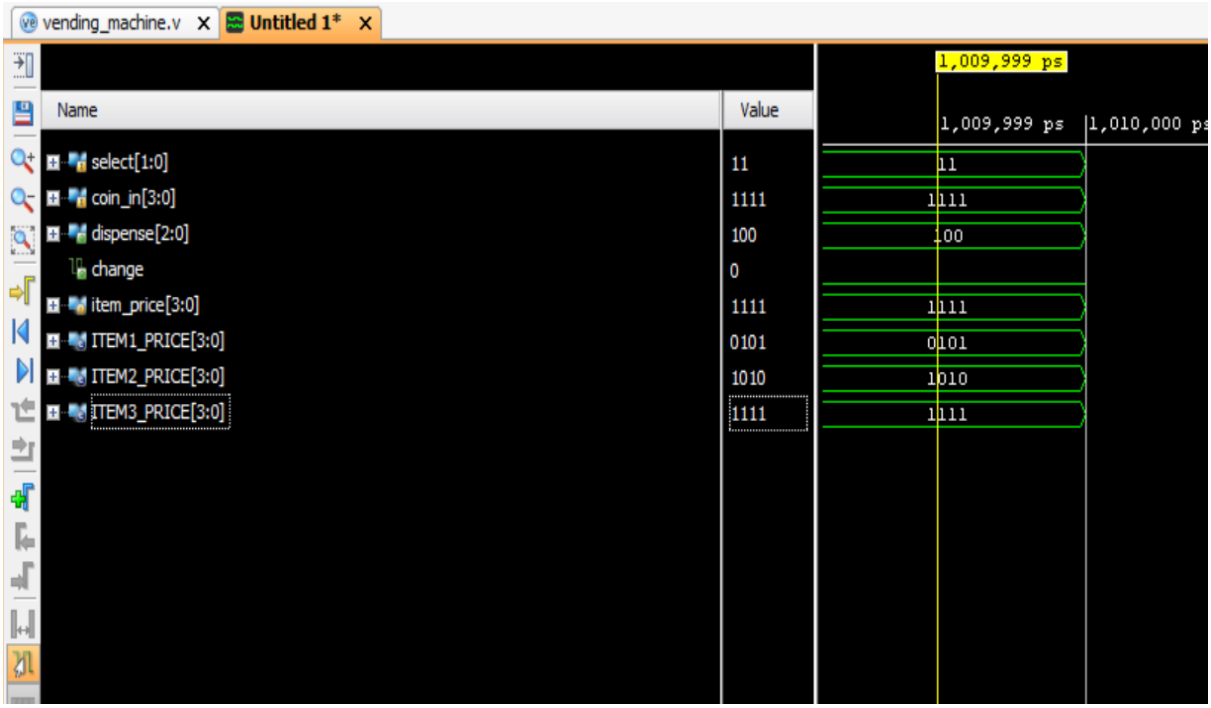
- Enter the code

```
module vending_machine(
input wire [1:0] select,  // 2-bit selection input for 3 items (01, 10, 11)
```

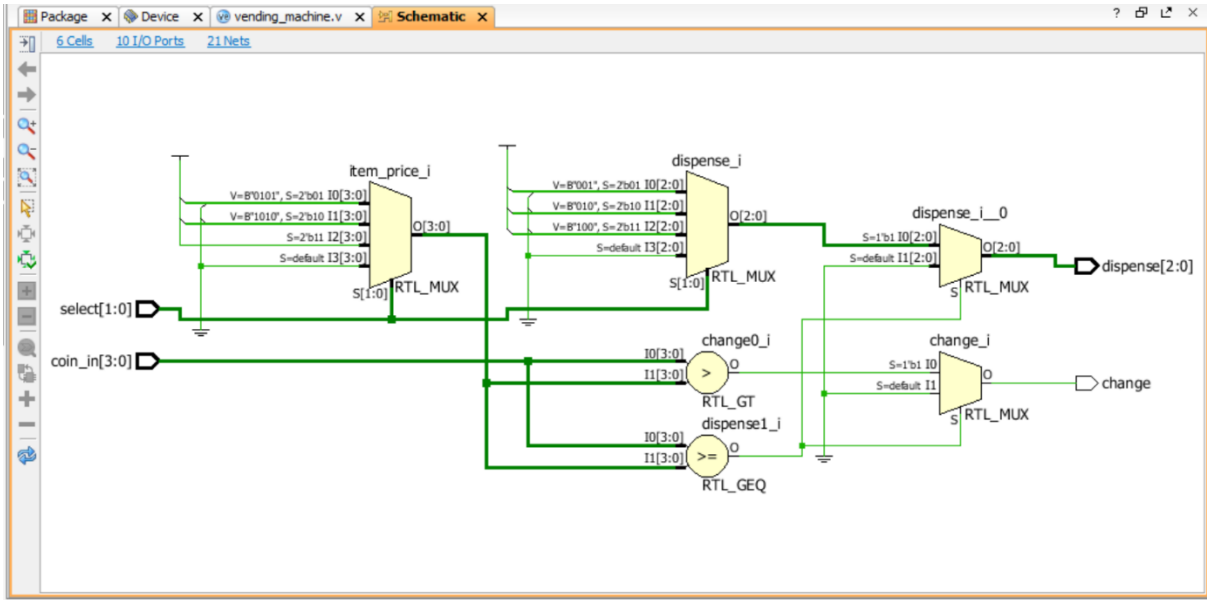
```
    input wire [3:0] coin_in, // 4-bit input for coins inserted (assuming each bit represents one coin)
    output reg [2:0] dispense,// 3-bit output for dispensing items
    output reg change         // Change return signal
);

    // Item prices
    localparam ITEM1_PRICE = 4'd5;
    localparam ITEM2_PRICE = 4'd10;
    localparam ITEM3_PRICE = 4'd15;

    // Internal registers to store selected item price and required coins
    reg [3:0] item_price;

    always @(*) begin
        // Default values
        dispense = 3'b000;
        change = 1'b0;
        item_price = 4'd0;

        // Determine item price based on selection
        case (select)
            2'b01: item_price = ITEM1_PRICE;
            2'b10: item_price = ITEM2_PRICE;
            2'b11: item_price = ITEM3_PRICE;
            default: item_price = 4'd0;
        endcase
```

```
        // Check if enough coins are inserted and dispense item
        if (coin_in >= item_price) begin
            case (select)
                2'b01: dispense = 3'b001; // Dispense item 1
                2'b10: dispense = 3'b010; // Dispense item 2
                2'b11: dispense = 3'b100; // Dispense item 3
                default: dispense = 3'b000;
            endcase

            // Set change if more coins are inserted than required
            if (coin_in > item_price) begin
                change = 1'b1;
            end else begin
                change = 1'b0;
            end
        end else begin
            // Not enough coins, no dispense, no change
            dispense = 3'b000;
            change = 1'b0;
        end
    end
endmodule
```

- Go to Run simulation>Run behavioral simulation>Give force constant to inputs i.e, binary values



- In RTL analysis>open elaborated design



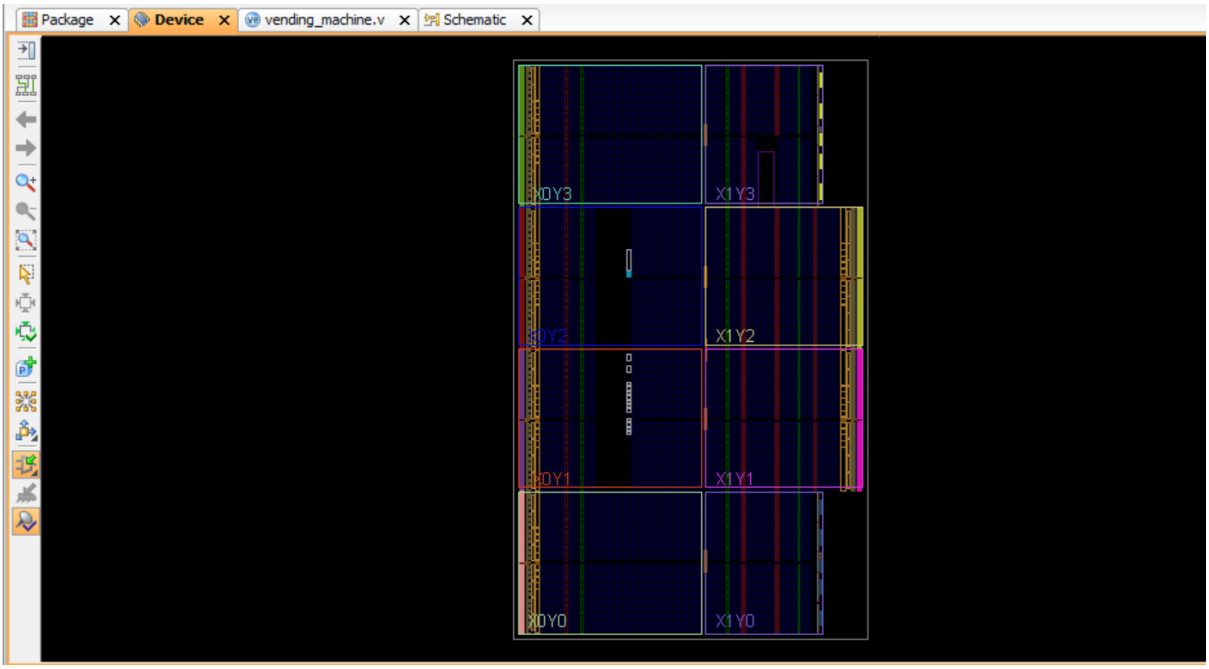
- In schematic window, on the top change the “default Layout” to “I/O planning”
- Go to I/O ports [bottom panel]>select scalar ports

- Give I/O std as LMCMOS33
  Go to package pins>Give input as coin_in[3]:P4, coin_in[2]:P3 , coin_in[1]:R3, coin_in[0]:T1, select[1]:T3, select[0]:U2 and output pins as dispense[2]:U3, dispense[1]:U4, dispense[0]:U6, change:U7

- Select save constraint [below edit button]
- From flow navigator>select Run suynthesis
- After successful synthesis>A pop appears>select Run implementation>click ok
- After finishing, another pop up appears, before selecting any option; connect the FPGA kit to CPU
- After Bit stream generation>choose open implementated design
- In flow navigator>program and debug>open hardware manager

  At top [green bar]>select open target>Auto connect

  At same bar>Program device>select the one which is shown>program



Truth table:

select	Coin_in	item_price	dispense	change
00	0000	0	000	0
00	0001	0	000	0
00	0010	0	000	0
00	0011	0	000	0
00	0100	0	000	0
...	...	...	...	...
00	1111	0	000	0
01	0000	5	000	0
01	0001	5	000	0
01	0010	5	000	0
01	0011	5	000	0
01	0100	5	000	0
01	0101	5	001	0
01	0110	5	001	1
01	0111	5	001	1
01	1000	5	001	1
01	1001	5	001	1
01	1010	5	001	1

select	Coin_in	item_price	dispense	change
01	1011	5	001	1
01	1100	5	001	1
01	1101	5	001	1
01	1110	5	001	1
01	1111	5	001	1
10	0000	10	000	0
10	0001	10	000	0
10	0010	10	000	0
10	0011	10	000	0
10	0100	10	000	0
10	0101	10	000	0
10	0110	10	000	0
10	0111	10	000	0
10	1000	10	000	0
10	1001	10	000	0
10	1010	10	010	0
10	1011	10	010	1
10	1100	10	010	1
10	1101	10	010	1
10	1110	10	010	1
10	1111	10	010	1
11	0000	15	000	0
11	0001	15	000	0
11	0010	15	000	0
11	0011	15	000	0
11	0100	15	000	0
11	0101	15	000	0
11	0110	15	000	0
11	0111	15	000	0
11	1000	15	000	0
11	1001	15	000	0
11	1010	15	000	0
11	1011	15	000	0
11	1100	15	000	0
11	1101	15	000	0
11	1110	15	000	0
11	1111	15	100	1

Conclusion:

In conclusion, my project on an FPGA-based vending machine highlights the power of combining modern technology with traditional vending concepts. Using FPGA technology, the vending machine can efficiently process transactions, manage inventory, and provide quick, reliable service. This approach not only improves the machine's performance and reliability but also makes it more adaptable to future advancements. Overall, an FPGA-based vending machine offers a smarter, more efficient solution for automated retail, enhancing the convenience and experience for users.

Key Achievements of FPGA-Based Vending Machine:

Enhanced Efficiency:

- Fast and reliable transaction processing.
- Reduced response time for product selection and dispensing.

Improved Inventory Management:

- Accurate tracking and real-time monitoring of stock levels.

Customization and Flexibility:

- Easily reprogrammable system for different products and configurations.
- Flexibility to update functionality without major hardware changes.

Cost-Effective Solution:

- Reduced costs compared to traditional microcontroller-based systems.
- Lower maintenance costs due to FPGA robustness and reliability.

Advanced Features:

- Integration of cashless payments and touchscreens.
- Remote monitoring and diagnostics for minimal downtime and efficient maintenance.

Scalability:

- Scalable design for future expansion and additional features.
- Easy upgrades and improvements as technology evolves.

These achievements demonstrate the advantages and potential of FPGA technology in enhancing the functionality and efficiency of vending machines.