Design and Simulation of Smart Vending Machine using Microcontroller & FPGA

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Abstract— A vending machine is a machine which provides various items like chock let, chips ,snacks, milk product, snacks, beverages, lottery tickets, consumer products and even gold and gems to customers automatically whenever the customer inserts coin into the machine. Vending machines are very common in most of the countries. In INDIA like Haldiram vending machine is going to be popular. As the world is switch into automation the requirement of vending machine also increases. The FPGA based vending machine is reprogrammed whereas the Embedded based machines needs to change to change the architecture. In this paper of vending machine using Finite State Machine (FSM) Model is proposed with the help of Arduino and GSM module. The sensor used here is temperature. The automatic notification is given to the concern person. The notification gives the real time product dispatch details. VHDL based FSM modelling is the most important part in developing vending machine model as this reduces the required hardware.

Key words: FSM, GSM, Temperature Sensor

I. INTRODUCTION

Vending Machines are used to dispense various products like Snacks, Water pouch, etc. when money is inserted into it. Vending Machines have been in existence since 1880s. The first commercial coin operated machine was introduced in London and England used for selling post cards. The finite-state automaton is set of all possible states and controls transitions from state to state in response to external input. It also called FSM or finite state automaton (FSA). It is a mathematical tool used to describe processes involving inputs and output [9]. It can divide FSM into two types: Moore and Mealy state machines. The Mealy machine is also called Synchronous FSM which is a state machine that uses only input actions, and the output depends on the inputs and present state. Moore Machine also called as Asynchronous FSM is a state machine that uses only entry actions, of and the output depends on the present state. The advanced improvement of current technology innovation and Cell phone, keen method for living has ended up being a noteworthy part in the present period of human life. GSM technology dominates Bluetooth, etc., technology, because it is limited to certain area [1]. GSM can be accessed throughout the country. FPGA based electronic security system with sensor interface through GSM can be achieved by monitoring Status of the appliances sent via SMS through GSM module and controlling the home appliances. The vending machines are more accessible and practical than the convention purchasing method. Nowadays, these can be found everywhere like at railway stations selling train tickets, in schools and offices vending drinks and snacks , in banks as ATM machine and provides even diamonds and platinum jewelers to customers. Previous CMOS based machines are more time consuming than the FPGA based machines.

II. RELATED WORK

The few researchers were analyzed the design of Vending Machine with different features. Similarly, Seenuvasan T, Saranya P [3] proposed a new approach to design an FSM based Vending Machine with auto-billing features. While, the FPGA based VM with features like SMS alert system, cancel feature were not detailed described & analyzed in many work.

According to the research paper [1] authors have an idea of wireless electronic security system with sensor interface through GSM. FPGA board which are activated and deactivated through commands in serial communication from cell. Status of the appliances sent via SMS through GSM module to a predefined numbers programmed in system.

Regarding the efficiency of Vending Machine, many researchers have been investigated the algorithm of the VM. Anchor Katiyar [6] proposes a VM is an efficient algorithm for implementation of vending machine on FPGA board. Because FPGA based vending machine give fast response and uses less power than the microcontroller based vending machine. The FPGA based vending machine supports four products and three coins.

According to the research paper, [8] authors have described an idea of MEALY Machine Model is used to modeled the process for state i.e. user selection, waiting for money insertion, product delivery and servicing. The Spartan 3 development Board is used to test the proposed model.

In [4] vending machine using Finite State Machine (FSM) Model is proposed using VHDL. FSM modeling is the most important part in developing proposed vending machine model as this reduces the required hardware. In this project MEALY Machine Model is used to model the process for state i.e. user selection, waiting for money insertion, product delivery and servicing. In these modern days, Reverse VM is very popular in different countries. It saves time and energy of the system that increase the efficiency of VM.

III. PROPOSED ARCHITECTURE

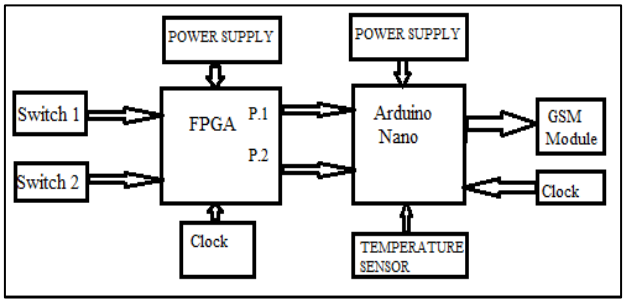

Fig. 1: System Block Diagram

The above system shows the block diagram of proposed vending machine. It consists of FPGA Spartan 3 XC3S50 with Arduino Nano, Temperature sensor and GSM module. System consists of two products which can be selected by switch 1 and switch 2.The product is selected by switch and available on P1. The microcontroller receives the signal and sends the SMS by using GSM module. Similarly product 2 is available. The clock is required for processing the instruction. Temperature sensor is used to sense the temperature and send a SMS if the temperature exceed then the threshold value.

IV. FINITE STTE MACHINE

A finite state machine (FSM) or finite-state automation or simply a state machine, is a mathematical model used to design both computer programs and sequential logic circuit

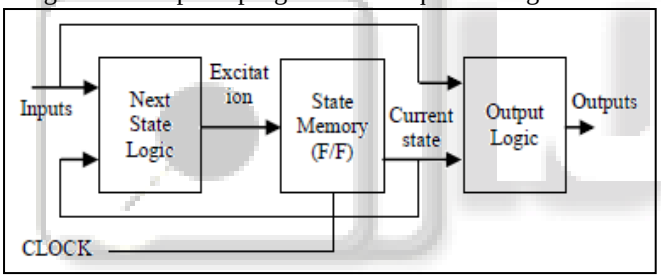

Fig. 2: Mealy machine model

A state register is used to hold the state of the machine and a next state logic to decode the next state. An output register holds the output of the machine. Hardware in FSM based machine is reduced as the whole algorithm is explained in single process. In this paper Mealy machine based model is proposed.

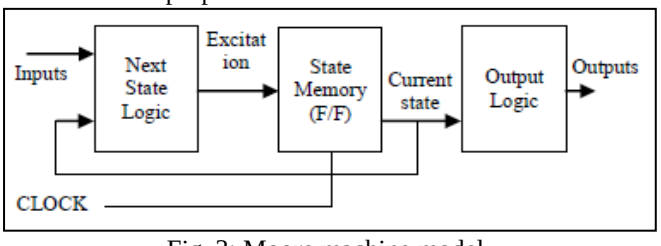

Fig. 3: Moore machine model

In the theory of computation, a Mealy machine is a Finite state machine that generates an output based on its current state and input. For each transition both input and output signals will be present in state diagram. Whereas in Moore machine the outputs are determined by the current state alone.

V. HARDWARE REQUIREMENT

A. GSM SIM 800:

This module takes the responsibility of sending a message to the registered user. It is done with the help of SIMCOM-800. It can send or receive messages from the registered mobile number. The main intention of using GSM is to provide an access to the user though his Internet connection is not active. To check the working of this GSM, a message can be sent by use of Arduino Nano.

B. ARDUINO NANO

Arduino Nano is a small, complete and breadboard-friendly board based on ATmega328/168. It is powered via Mini-B USB connection, 6-20V unregulated external power supply or 5V regulated external power supply, has 32KB memory and has 14 Digital Pins. It takes input from FPGA board and accordingly gives output to Arduino IDE software via 2.4GHz wireless module.

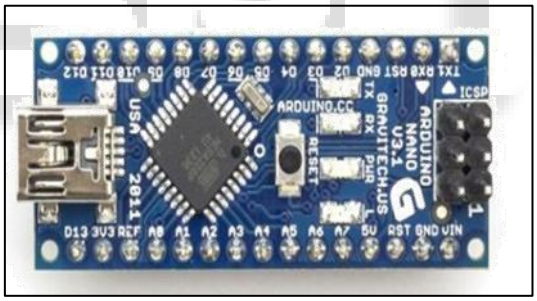

Fig. 4: Arduino NANO

C. Temperature Sensor (LM35):

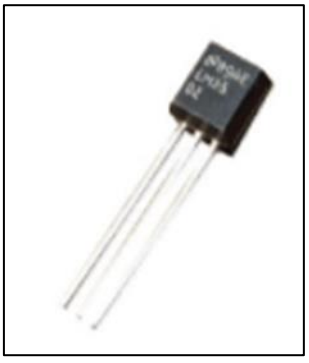

Fig. 5: LM 35

Temperature Sensor is basically used for measuring temperature variations around the sensor. LM35 is highly accurate temperature sensor used for research purposes. LM35 has varied features like: Direct calibration in Celsius degree; measures temperature ranging from -55 to +150 degree in Celsius.

D. Hardware System Model:

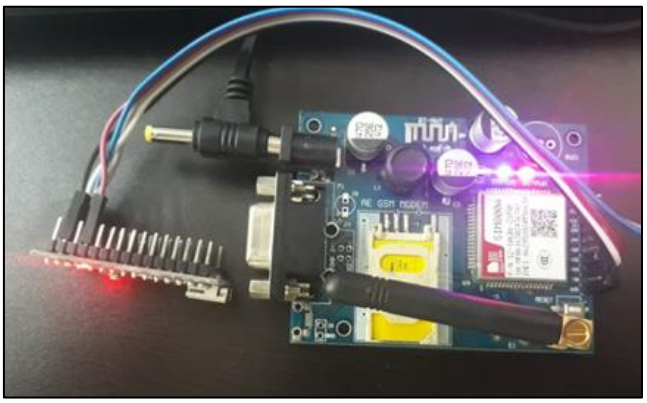

Fig. 6: Hardware system model

VI. EXPECTED OUTCOME & FUTURE WORK

The expected requirements of the vending machines are increasing day by day due to the modern and fast life style. This FPGA based vending machine will be used at remote location for fast & accurate dispense of some products for domestic purpose at various public places. We can monitor the FPGA based vending machine with the main frame computer. Its algorithm is very flexible and reliable as the vendor can easily enhance the algorithm for large number of products and money of different denominations at low cost as compared to microprocessor based vending machine. The Vending Machine is expected to fulfill following expectations....

- RTL level design for implementation of ASIC.
- Comparative analysis with other CMOS family.
- Cost benefits analysis of vending machine.
- GSM based response for users about billing & security.

This designed vending machine will be modified for dispensing various multiple products, at the same time which will be more comfortable for users. Simultaneously, cancel request, auto -billing & card payment facility features will also be added by FPGA implementation. Also, it will be monitored through main frame computer.

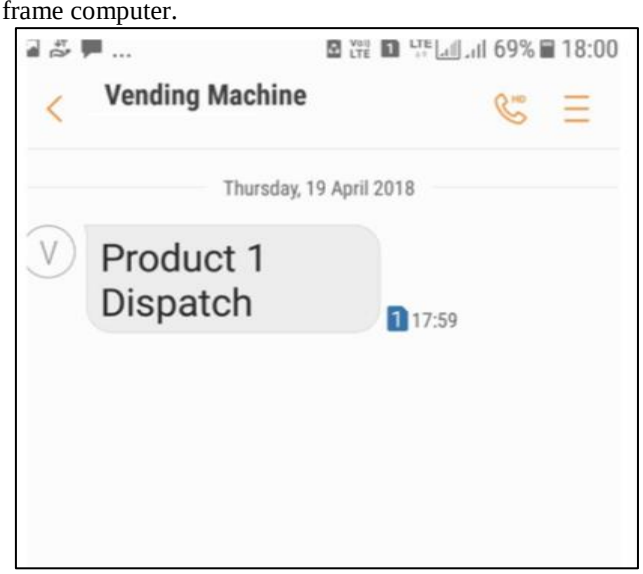

Fig. 7: Product 1 dispatch screenshot

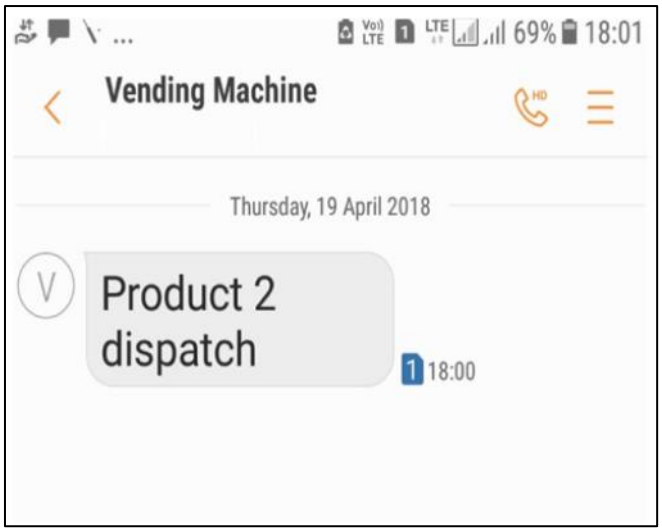

Fig. 8: Product 2 dispatch screenshot

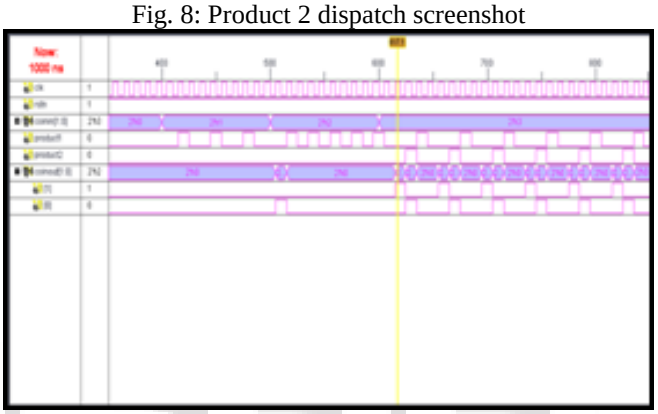

Fig. 9: Simulation Waveform

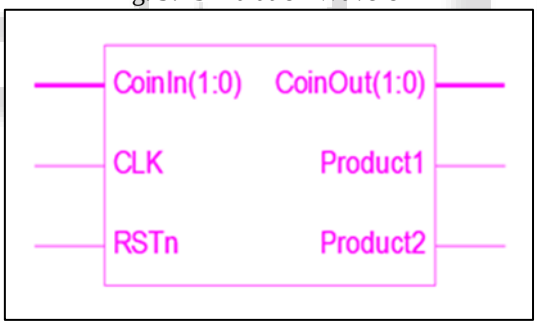

Fig. 9: RTL View

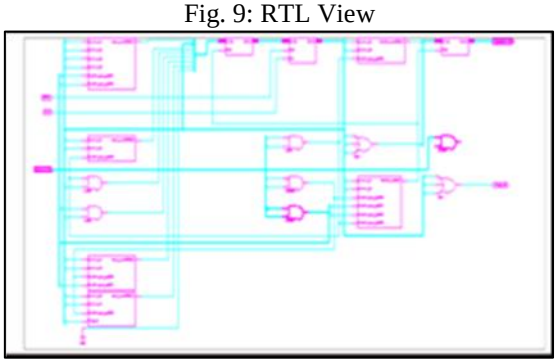

Fig. 10: TOP level Entity

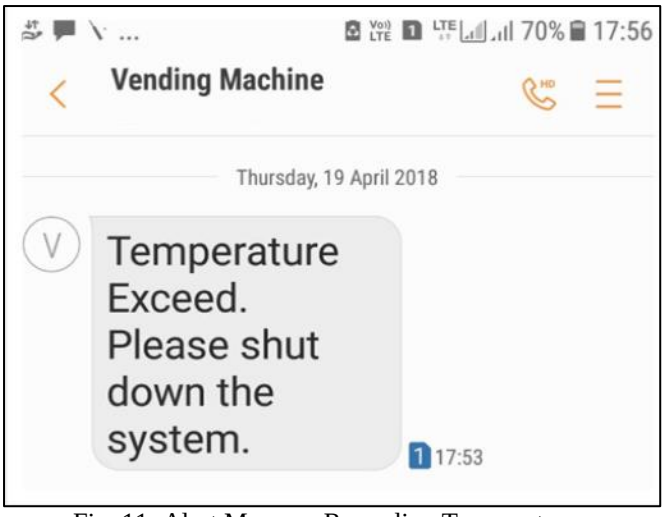

Fig. 11: Alert Massage Regarding Temperature

VII. AREA UTILIZATION SUMMARY

Sr. No.	Logic Utilization	Used	Available	Utilization
1	No.of Slices	6	3584	0%
2	No. of slice Flip Flops	8	7168	0%
3	No. of 4 input LUTs	12	7168	0%
4	No. of Bounded IOB's	8	141	5%
5	Number of GCLKs	1	8	12%

The proposed model is design and check on Spartan3 XC3S50.The minimum period required is 2.669ns. The maximum frequency is 374.609MHz. The combinational path delay required is 7.985ns.

VIII. CONCLUSION

The design and simulation of an automatic vending machine is functionally verified using Xilinx ISE simulator and combinational path delay found to be7.985ns.The simulation is done on Xilinx ISE. The hardware is work properly which gives alert message. The vending machine is design and simulated for two products. Its algorithm is very flexible and reliable as the vendor can easily enhance the algorithm for large number of products and coins. The system gives notification via GSM modem if the product is dispatch. The temperature sensor is used which gives temperature value which is helpful for the food and liquid product to maintain its temperature.

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