

Implementation of Reverse Vending Machine Based on FPGA

Sakshi Sharma¹, Ana Monga²

Department of Electronics and Communication

DAV Institute of Engineering and Technology, Jalandhar, Punjab, India

ABSTRACT: In these modern days, Reverse Vending Machine is very popular to Korea, Japan, England, Britain, Greece and China. Reverse Vending Machine saves time, employee work and also save human's energy. This paper describes about the Reverse Vending Machine which works after inserting the empty beverage container into it. The project of Reverse Vending Machine (RVM) is useless without the cooperation of consumer. This is very attractive and motivated prize for the consumer through the RVM i.e. Refund. This paper addresses the implementation of Reverse Vending Machine based on FPGA. RVM is based on that process in which a machine accepts empty remaining containers and gives output according to the number of container. In this Paper, RVM supports empty containers, coins, snacks, chocolate, cold-drink etc. The algorithm for it is implemented in VHDL and simulated using Xilinx FPGA Spartan 3 development board.

KEYWORDS: Reverse Vending Machine; FSM; FPGA Spartan 3 development board.

I. INTRODUCTION

From the most recent years, reverse Vending Machine is rising meaningfully day by day. This machine is popular in that country where recycling laws or container deposit legislation is required. It becomes a very big difficulty because there is no space anywhere for landfill and dioxin emission. This dioxin emission from incineration is very harmful for human health [4]. There are several types of Vending Machines in this world like Single selection, double selection and triple selection Vending Machines. From the Single selection Vending Machine, user can dispense only one kind of product; where In Double Selection, two types of product; in triple selection, and three types of product for example tea, coffee, cold drink. Similarly, a lot of Reverse Vending Machines are also there [5]. Here in this Paper, we planned to implement the Reverse Vending Machine on FPGA Board. The main resolution to make Reverse Vending Machine is to prevent the environment from pollution of waste material. In this Machine when the consumer inserts empty can into it, only then it works. In Future Modern days, these can be available the world over like at railway stations, in schools and offices, in banks etc. Earlier CMOS and SED based machines are more time consuming as compared to the FPGA based machines. These machines are more flexible, programmable and can be re-programmed where as in microcontroller based machine, if one wants to improve the design, he has to change the whole architecture again but in FPGA user can easily increase the number of products [2].

This Block Diagram also shows the procedure for Reverse Vending Machine that how it will work. In this, it shows empty used container acts as an input for the machine which passes to the Sensor. Sensor checks that Is the Container received? According to that, counter counts quantity of received containers and gives output [6]. Output of Reverse Vending Machine can be any gift or coins as explained in table II.

A. Operation of Reverse Vending Machine

This is the main Procedure for the execution of Reverse Vending Machine. It has three main steps i.e. Input, Process and Output. Where incase of Process, it means Sensor and Counter. Operations are:

- When the user collects their products from Vending Machine.
- After using those products, unused wrapper remains.
- When the consumer puts that wrapper in reverse Vending Machine then he will get coins or products on the basis of no. of wrappers [1].

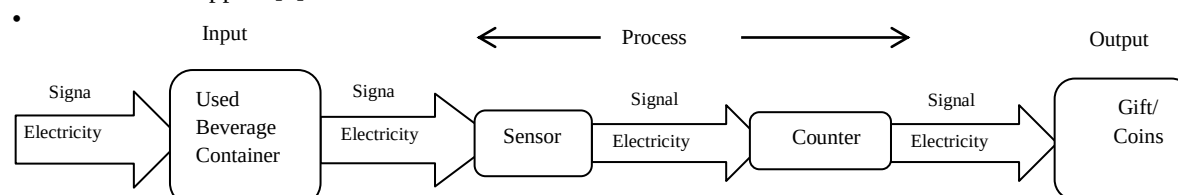


Fig. I: Block Diagram of Reverse Vending Machine

II. ALGORITHMIC STATE MACHINE DIAGRAM

The Algorithmic State Machine Diagram consist two main states in which it receives returned item as an input. In the second step, Sensor checks that containers are received or not? In the third step, Counter is there. It checks that how many containers are received. If the quantity of container is less than five then output gets two coins per empty container but if number of container increases from five then product will be out as an output [3].

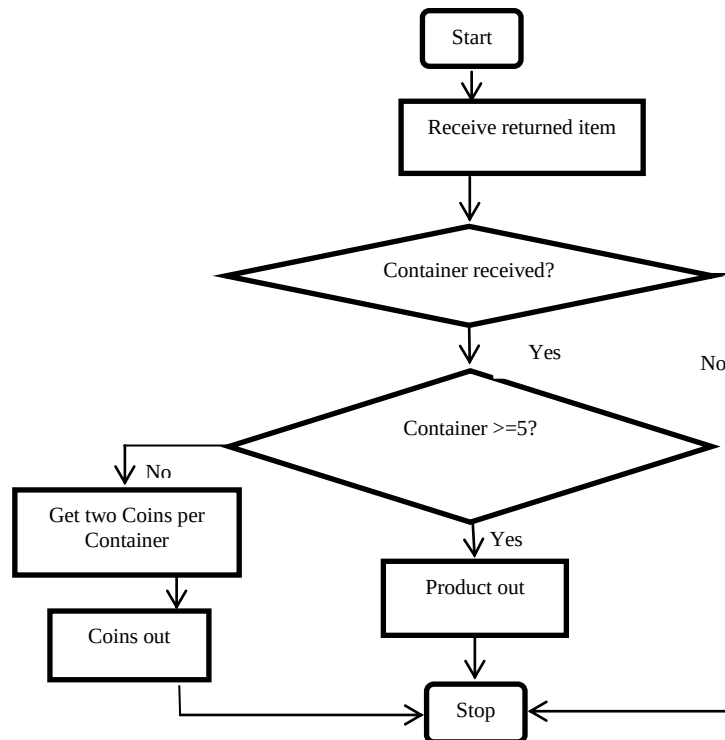


Fig. II: Algorithmic State Machine Diagram of Reverse Vending Machine

Let us assume if the consumer inserts two containers inside the machine. Sensor will pass those empty cans to the counter after sensing that cans have been received. Counter will count the quantity of containers and give the output according to two coins per container. So in this case, the machine will give two coins as an output to the consumer. If there is any change, machine can cancel all the statements. Once getting the output, if user wants to insert more containers into machine then they can because it resets again.

III. RELATED WORK

After the study of various researches about Reverse Vending Machine, it is found that Michiko Amano proposed a paper on the PET (Polyethylene terephthalate) Bottle System. In which the process is emphasized on recycling system [4]. In [6], European Patent Application describes the Method and apparatus for detecting fraud attempts in reverse vending machines. Various three methods for designing of Vending Machine are discussed in [1], [2] and [4]. In [10], this article introduces a payment that is based on mobile short messages, vending machine being real-time and on-line, and cell phone messages code being the control command to coordinate people to finish the shopping. A method for monitoring activities at a ticket vending machine in a video-surveillance context rather than relying on the output of a tracking module, which is prone to errors discussed in [8]. Paper [5] addresses a mobile payment solution where there is no connection required for the vending machine, and while the local means of communication is through infrared (IR).

IV. FINITE STATE MACHINE (FSM) DIAGRAM

Our Scheme contains two different modules as explained in Figure III. In First Module, condition is; if the number of empty cans less than five. Where in Second Module, amount of empty cans greater than and equal to five [3]. In the beginning; when reset key is pressed, Reverse Vending Machine starts to work. This is the initial state (St0). If containers are received after checking by sensor then it will move on the wait_1 state. At here; according to two modules of reverse vending machine, it will move on the states whether i.e. st1 or st2. Next Processing depends on those modules. For Example, if the quantity of container is less than 5 means ins_cont signal is less than five then next state will be st1, but if the signal ins_cont greater than or equal to five then next state will be st2 but otherwise st3. In the next stage, the machine will give output according to number of containers as shown in the table1. FSM is of two types i.e. MOORE Machines and MEALY Machine. In this

Paper, Mealy Machine Model is used because its output depends on present state as well as current input [1], [2]. Mealy machines have a clock input

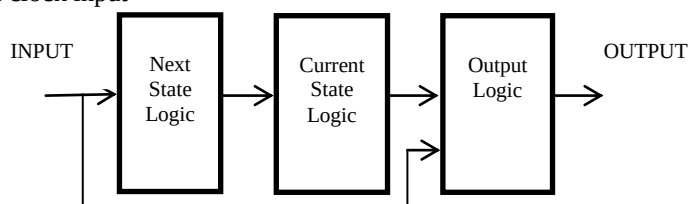


Fig. IV: MEALY Machine

and are also called Synchronous FSMs, while Moore Machines are without clock input and are also called asynchronous FSMs. Mealy Machine is a Finite State Machine and it is a method for synthesizing sequential circuits.

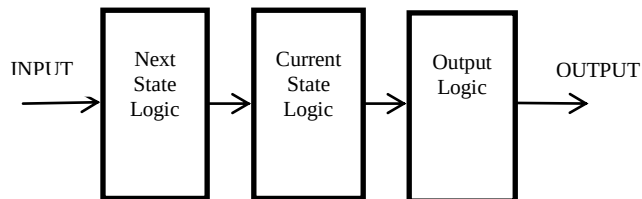


Fig. III: MOORE Machine

V. IMPLEMENTATION OF REVERSE VENDING MACHINE

Overall description about the implementation of Reverse Vending Machine shows in the table I and II. In this Paper, reverse vending machine is constructed in terms of state diagrams. The Customer can get four different types of Products and Coins as explained in Table II. The Machine can accept the empty containers as an input.

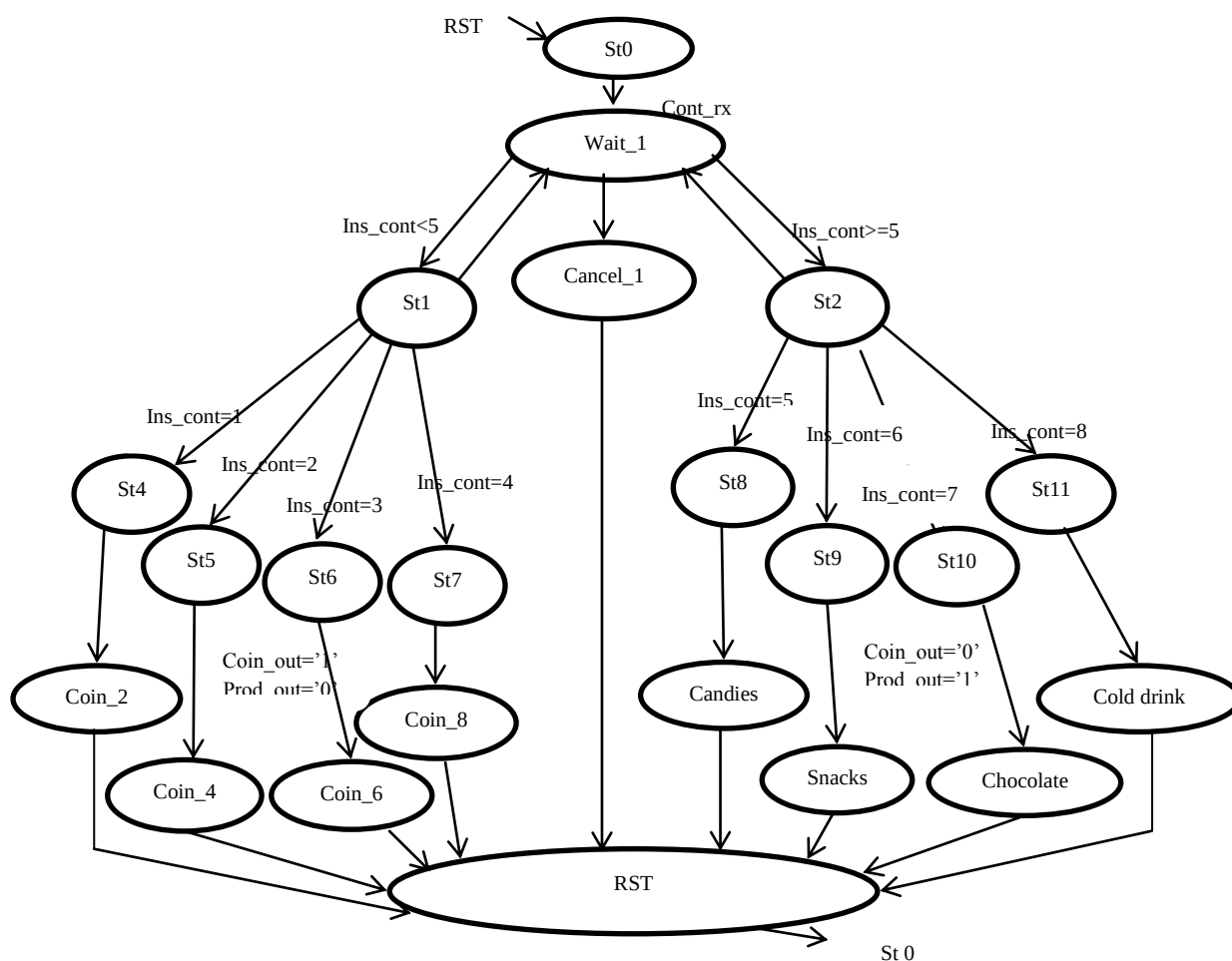


Fig. V: Finite State Machine Diagram of Reverse Vending Machine

A. Description of states

The selection of coins/ products and all the states are shown below in figure V. In this, st0 is initialization state. Input States are st1, st2, st3 and st4; st5, st6, st7, st8, st9, st10, st11 are output states. In these states; prod_out, coin_out means output as a product and output as coin respectively. The Signal Cont_rx means container received/ not received by the machine and after that machine will proceed. An Ins_cont is used for inserted containers into the machine by consumer. Cancel_1 is the cancel button used to cancel all the statements, if no container is detected by the machine [6]. There is a condition in this FSM Chart i.e. if the quantity of containers smaller than five then the machine will give coins as output like two coins per container but if the quantity of empty beverage container increases from five then it will give product as output like snacks, candies, chocolate and cold drink as explained in table II.

- When st0 (reset state) =>
prod_out <=0;
coin_out=0;
- When st1=>
ins_cont<5;
coin_out=1;
- When st2=>
ins_cont>=5;
prod_out =0;
- When st3=>
cancel_1='1';
- When st4=>
coin_out=1;

Table I: Input/ Output with remarks

Name	Width	Direction	Description
CLK	1	Input	Clock
RST	1	Input	Sync Reset
Cont_rx	1	Input	Container received
Ins_cont	4	Input	Insert Container by consumer
Coin_out	1	Output	Output as Coin
Prod_out	1	Output	Output as Product
Pr_state	1	--	Present State
Nx_state	1	--	Next State

Table II: Description of Coin_out/ Prod_out

Sr. No.	INPUT	OUTPUT	
	Number of Empty Containers	Coins	Product
1.	1	2 Coins	--
2.	2	4 Coins	--
3.	3	6 Coins	--
4.	4	8 Coins	--
5.	5	--	Candies
6.	6	--	Snacks
7.	7	--	Chocolate
8.	8	--	Cold-Drink

```

prod_out =0;
When st5=>
    coin_out=1;
    prod_out <=0;
When st6=>
    coin_out=1;
    prod_out <=0;
When st7=>
    coin_out=1;
    prod_out <=0;
When st8=>
    coin_out=0;
    prod_out =1;
When st9=>
    coin_out=0;
    prod_out =1;
When st10=>
    coin_out=0;
    prod_out =1;
When st11=>
    coin_out=0;
    prod_out =1;

```

In this Machine there are two main states i.e. Cont_rx and Ins_cont. Where Cont_rx means container received/ not received by the machine and Ins_cont means inserted container into the machine. It means if the containers

are received then machine will work otherwise it will reset again. After that at the next state, consumer will insert the container in the state `ins_cont`. `Ins_cont` is of 4-bit wide. So, its value can be varying from 0 to 7. If the quantity of containers less than five then the machine will give output as coins but if its value move from five to eight then its output will be a product [3]. The Description of output is according to that whether the machine will give output as coins or product. It shows in the table III.

The Description of Product and coins according to the input of empty beverage containers are explained in table II. In which it shows the machine will give coins if the number of containers are less than five and give product if the quantity of container increases from four. The Output will be two coins if the inserted container is one. For two empty containers, output will be four coins; for three, four containers, six, and eight coins respectively.

VI. DESIGN METHODOLOGY

A. RTL View for RVM

In the digital circuit design, Register Transfer Level (RTL) is a design in which a synchronous digital circuit in terms of the digital signals between hardware registers and the logical operations performed on those signals. RTL is used in Hardware Description Language (HDL) for creating the high level representations of a circuit. In this Paper, RTL View for RVM addresses that it has four inputs i.e. `cont_rx`, `ins_cont`, `reset` and `clock`. Similarly, it also has two outputs i.e. `coin_out` and `prod_out`. The Register Transfer Level for Reverse Vending Machine is shown in figure VI as:

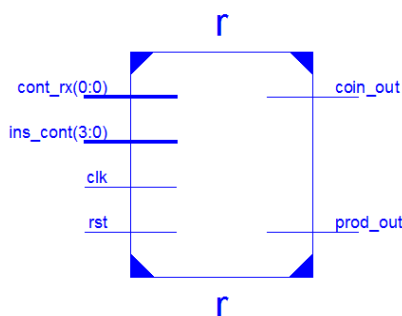


Fig. VI: RTL View

B. Technology Schematic for RVM

A Schematic Diagram is a representation of the elements of a system using abstract, graphic symbols rather than realistic pictures. Internal Technology Schematic View is as shown in figure VII. It shows a representation of the design in terms of logic elements optimized to the target technology. It includes look up tables, carry logic, I/O buffers and other technology specific components.

In Table III, Synthesized report is shown after creating the design file. This report checks code, syntax, analysis of design and recognizes the functions of code It includes number of slices, flip-flops, look up tables and bonded input outputs used.

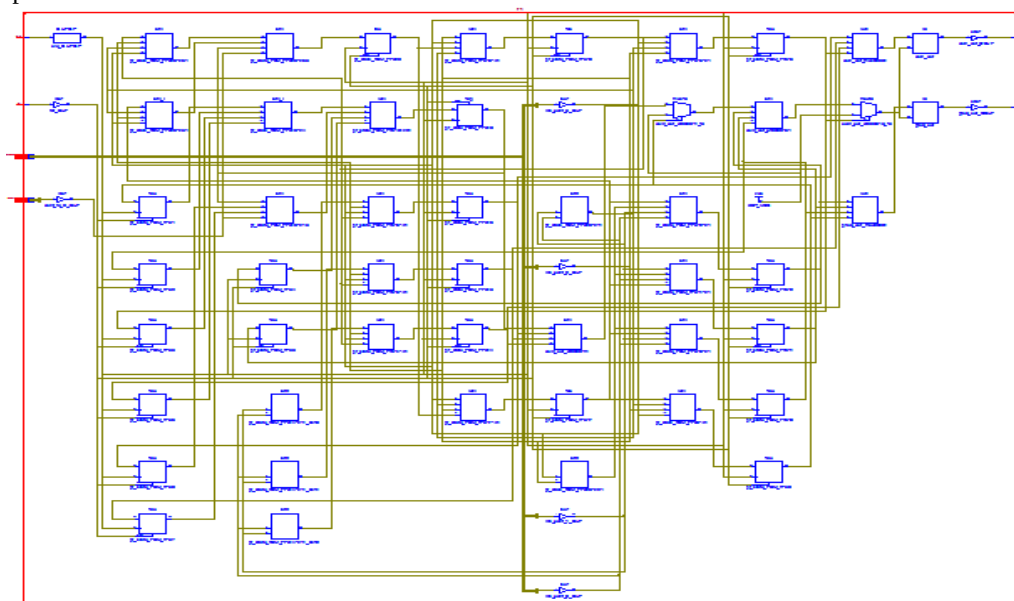


Fig. VII: Technical Schematic View for RVM

The Synthesized Report for RVM describes the area utilization of Xilinx Spartan3 Development Board.

Table III: Synthesized Report

LOGIC UTILIZATION	USED	AVAILABLE	UTILIZATION
Number of Slices	19	4656	0.004%
Number of Slice Flip-Flops	25	9312	0.003%
Number of 4 input LUTs	27	9312	0.003%
Number of Bonded IOBs	9	190	4%
Number of GCLKs	1	24	4%

VII. SIMULATION RESULTS

In figure VIII, IX and X; it shows Simulation results in case of either consumer getting coins or product. These Simulation Results are implemented in Xilinx ISE Simulator. Simulation Waveform for the output of Product and Coins are shown in figure VIII, IX and X respectively. One of the Cancel state is there in case if no one is inserting the empty container after pressing reset button [1], [2].

Let us consider example if one is inserting three empty containers. The Machine will wait till the insertion of complete empty containers. Then, it will move on the state st6 through st1 after the wait statement. At the state st6, it will give the output as 6 coins as explained in our condition from table II i.e. 2 coins per container. This output is shown in figure VIII.

Similarly, if anyone is inserting eight empty containers, then it will move on the state st11 through st2 and give the output as product because in st2 state; prod_out is high and coin_out is low. According to the table II, the machine will give cold drink for eight coins. So cold drink will be the output. This output is shown in figure IX. In the figure XI, this is the condition if the inserted container by consumer is zero after pressing the reset key. Where in this state, Cont_rx means machine is ready to receive the container. So, Cont_rx bit is high but by default no one is inserting anything into machine means ins_cont will be low. Output is shown as in figure X.

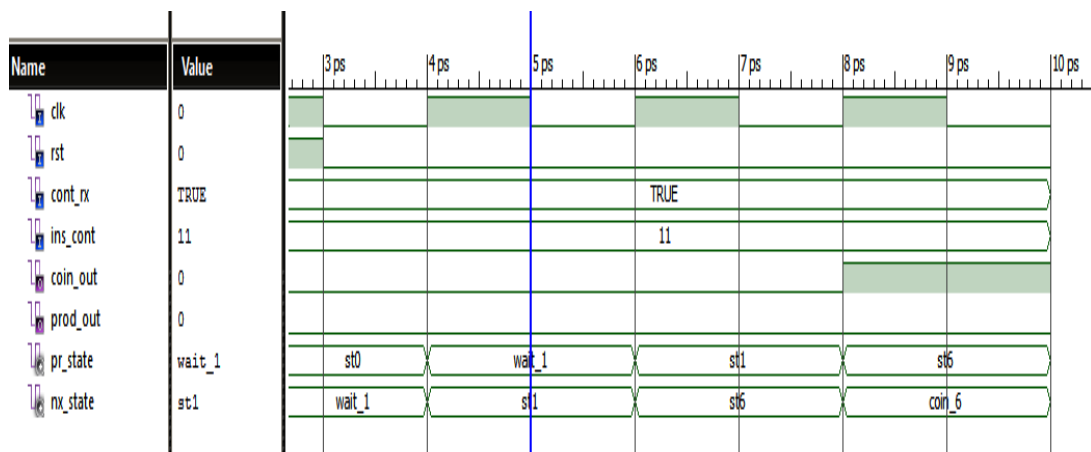


Fig. VIII: Simulation Results for three Empty Containers

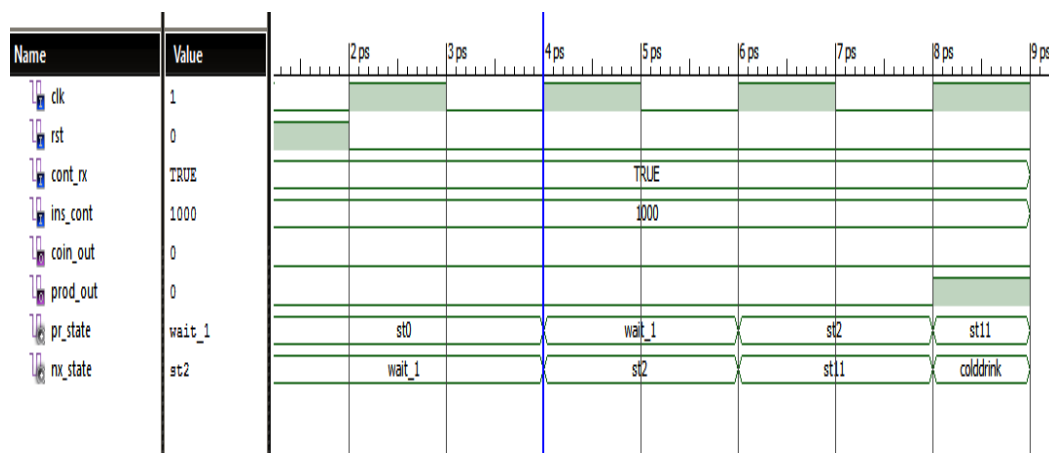


Fig. IX: Simulation Results for Eight Empty Containers

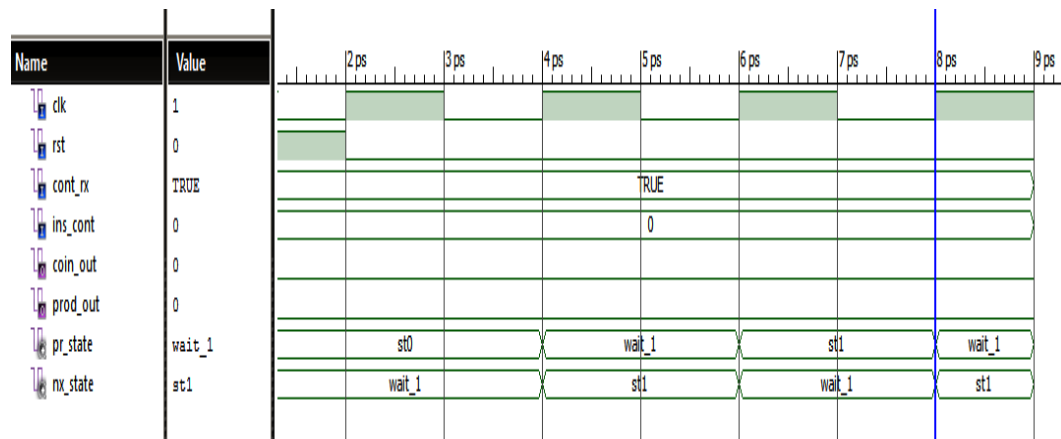


Fig. X: Simulation Results for RVM

VIII. CONCLUSION

On average nearly 25% of employees leave the office for about 15 minutes every day when companies do not supply the appropriate refreshments at work. A Perfect Choice Reverse Vending Machine can help to improve the work place productivity by implementing a complete refreshment program. In this paper an FPGA based Reverse Vending Machine is implemented using Xilinx 14.3 ISE Simulator. The next stage of this study is to implement this FPGA based Machine on hardware.

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