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A Simple Approach to Design Reverse Vending Machine

Aditya Gaur*
Department of Electronics & Communication Engineering
Sharda University, Knowledge Park
Greater Noida, India
Dilip Mathuria
Department of Electronics & Communication Engineering
Sharda University
Knowledge Park, Greater Noida, India
Dr. Rashmi Priyadarshini
Department of Electronics & Communication Engineering
Sharda University, Knowledge Park
Greater Noida, India

ABSTRACT— *These days the increasing in amount of waste generated by human's and limited landfill sites for dumping waste, recycling it is one of the novel approaches to manage the waste effectively. The present recycling practice in which the people need to bring the waste in bulk to the recycling centre might bother and become a discouraging factor for them to recycle. To overcome such an issue, an automated recycle bin designed and installed in many countries on subways, malls etc. with a reward featured is developed from a reverse vending machine (RVM) concept. In present time, Reverse Vending Machine is become very popular in countries like Greece, Japan, Europe, South Korea, America and China. Reverse Vending Machine(RVM) reduce employee work, saves time and energy also motivate human's being, even cost effective. In this paper we explain about the working of Reverse Vending Machine based on fraud detection sensors which start to work after inserting the plastic material into it and that plastic is checked by the series of sensors. There are very attractive rewards for the users of Reverse Vending Machine, they get coins as a reward. This paper explains the simulation of Reverse Vending Machine with fraud detection with Strain Gauge Weight Sensor, Capacitive Proximity Sensors and Infrared Photoelectric Sensor to detect fraud. Reverse Vending Machine process by accepting plastic items and gives coins as a reward according to the weight of plastic items. In this, Reverse Vending Machine supports only plastic items as an input, coins as an output. The Reverse Vending machine(RVM) is simulated and implement using Xilinx in Verilog.*

Keywords— Reverse Vending Machine; FPGA; FSM; Sensors; Frauds; Cost Effective.

I. INTRODUCTION

During the recent time, use of Reverse Vending Machine(RVM) is increasing day by day. Reverse Vending Machine collect popularity in those country where recycling laws or legislation is required. It becomes a major problem to dumped waste because in most of the country where landfill sites are already on their limits or cross their limits. When the waste materials get disposed they released harmful gases. This emission of gases is very harmful for the Earth and for species living on it [4]. The most important approaches for recycling the waste is to managing waste effectively. Reverse Vending Machine(RVM) is an efficient process and motivated way of collecting waste material. Recently in Malaysia, the government start campaign for the separation of waste at home starting from 2 September 2015. System Implement for the separation of waste material at home would involve state that adopting Act, which it will be Wilayah Persekutuan, Kuala Lumpur, Negeri Sembilan, Putrajaya, Pahang, Johor, Melaka, Perlis and Kedah. The recycling campaign was started in 1993 and this campaign has not met the objectives due to less commitment from the peoples and less serious

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of awareness about the program that has been done. In market there are many kinds of Vending Machines are available, we differentiate them on the basis of their output. First Vending Machine based on Single Selection, user can get only one type of item as an output. Second kind is based on Double Selection, user get two types of item as an output and so on for example coffee, tea, cold drink, etc. Similarly, Reverse Vending Machines are also differentiated on this basis of supporting number of items as an input and output there [5]. So, we planned to simulate the Reverse Vending Machine(RVM) on Xilinx along with Strain Gauge Weight Sensor, Capacitive Proximity Sensors and Infrared Photoelectric Sensor to detect fraud. The objective to simulate the Reverse Vending Machine(RVM) is to effectively managing the waste for recycling purpose and decrease the level of pollution. In proposed Reverse Vending Machine, the user inserts plastic items into machine after this machine start to work. In coming time, Reverse Vending Machine can be implement on subways, railway station, colleges, public places etc. Most of the Vending Machines and Reverse Vending Machines are based on microcontroller, CMOS and SED. They consume more time than FPGA based machines. FPGA based machines are more flexible, we have reprogrammed them whenever required, like we have to change the number of inputs and outputs items. Where as in microcontroller-based machines we cannot improve the design, we have to change the architecture again [3].

II. SYSTEM OVERVIEW

This section discusses the system modelling, process and theoretical design of the Smart Plastic Recycle Machine. It also describes the design flow which was used to implement the design.

A. Process of RVM

In this block diagram we explain the step procedure of proposed Reverse Vending Machine(RVM) working. In the block diagram waste plastic materials acts as an input and then check by several sensors. First machine check through the sensors that Is the plastic material received? Is the material made of Plastic? Is the plastic empty? According to that, weight sensor weighs the received plastic item and give output to user in form of coins as per the weight of item [6]. Output criteria is discussed in table I.

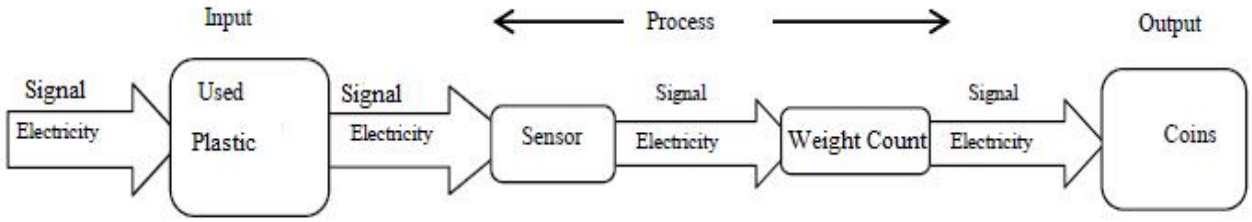

Fig. I: Block Diagram of Reverse Vending Machine

The operation of proposed Reverse Vending Machine has three main steps (Input step, Process Step, Output Step) operation as follow:

- The user Can insert plastic of any shape in Reverse Vending Machine.
- After inserting the plastic, it is checked by Three Sensors First checked by Capacitive proximity sensor, then by Infrared Photoelectric Sensor and at last checked by the strain gauge weight sensor.
- After that he will get coins on the basis of Weight of Plastic.

Capacitive Proximity Sensor: - This sensor is used for detection of metallic and non-metallic objects (plastic, tin, Aluminum, wood, etc.). It uses the variation of Capacitance between object and sensor.

Infrared Photoelectric Sensor: - This sensor is used to detect the presence of non-ideal thing as an input i.e. water, non-water-based fluids, stones etc. This sensor uses standard visible LEDs that pass-through water and detect it using 1450nm wavelength.

Strain Gauge Weight Sensor: - This sensor is used to determine the weight up to 1Kg of items. It is in the form of straight bar and translate Pressure or Force into an electrical signal.

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B. Flow Diagram

The flow chart of the Smart Plastic Recycle Machine. The flow starts by receiving the input, which is the plastic bottle or any other plastic thing. The sensor then detects the Plastic. If the sensor does not detect any Plastic, the flow comes to a stop. If the sensor detects a Plastic, the sensor sends Plastic to next sensor for water based liquid detection after this weight sensor check plastic weight and give different output according to weight range.

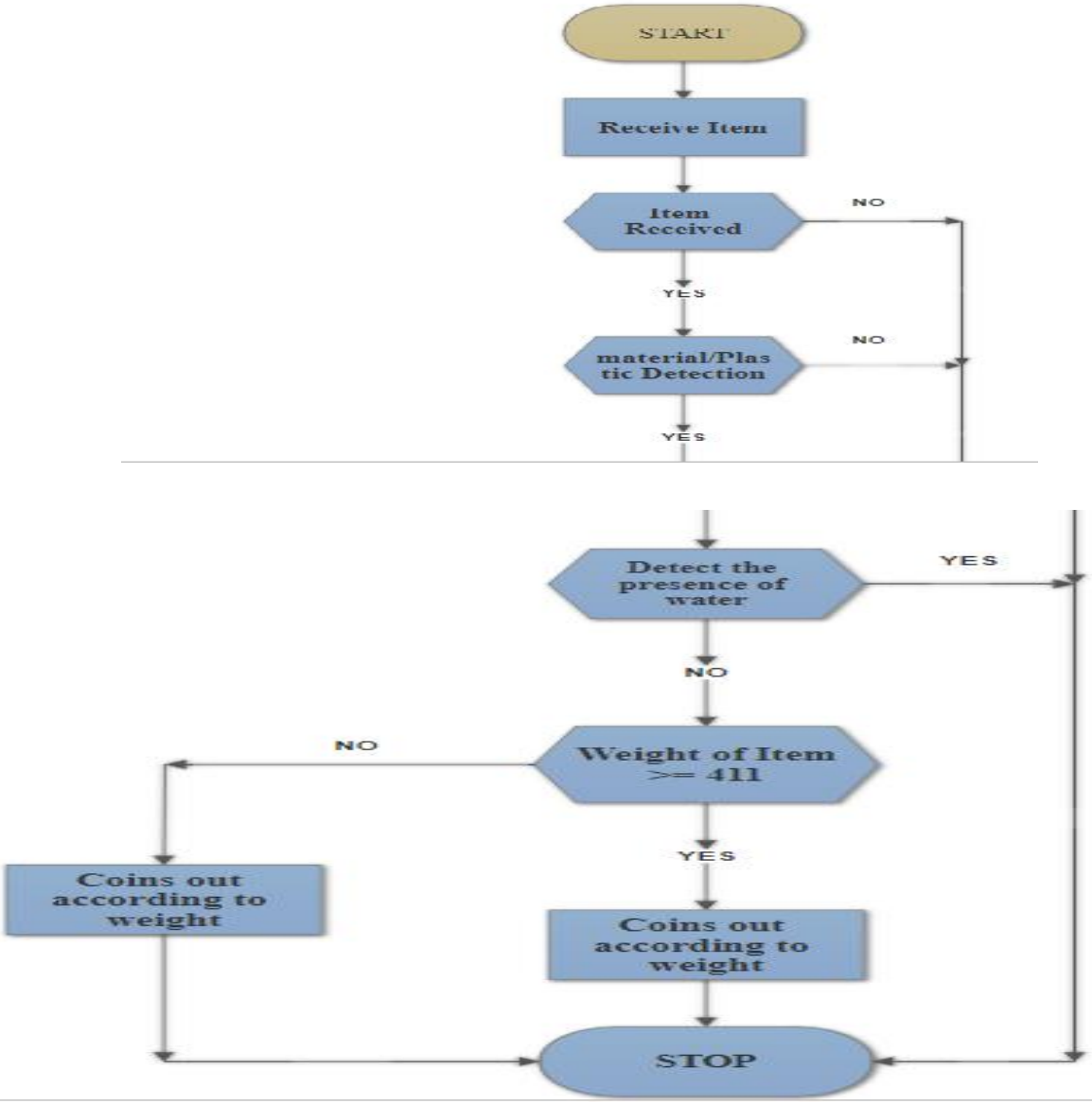

FIG II: Flow Diagram Reverse Vending Machine

III. LITERATURE REVIEW

After doing lots of literature study about Reverse Vending Machine(RVM) we found that Razali Tomari implement the frame work for Standard Recycle Bin System. In which the process is developed on Bin Processing Unit(BPU) [7]. In one Patent author explain the method for detecting fraud attempts by describing the component use in reverse vending machine and also in vending machine [6], [8], [3], [4]. In [10] author explain the real time implementation of vending machine at bigger level, where user enter in mart and mobile

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get code through messages. This code give guideline to user to finish the shopping. Another approach is discussed in [2] where vending machine which give token as output is monitored by a video surveillance context rather then depend on tracking output to reduce the error. In paper [5] discuss about the wireless connection between vending machine and user mobile for mobile payment.

IV. FINITE STATE MACHINE (FSM)

In proposed Reverse Vending Machine, we make two different module conditions in first, if the weight of received plastic waste is less than 411gm and in another the weight of received plastic waste is greater than equal to 411gm. User pressed reset button, reverse vending machine came into action at initial state st0. Next checked by all sensors and move to next state wait_1 now according to proposed module it move to next state either it is St1 or St2 it depends on weight of item. Further process is depending on weight how much coin did user get. It explains in Table I. MEALY Machine and MOORE Machine are the types of finite state machine(FSM). In this proposed method Mealy machine model is used. Difference between Mealy machine and Moore Machine is that mealy machine output is depends on the present state as well as on the current input [3], it has clock input and also known as synchronous type FSMs. In Moore machine output is depend on the current state and have no clock input, it is also known as asynchronous type FSMs.

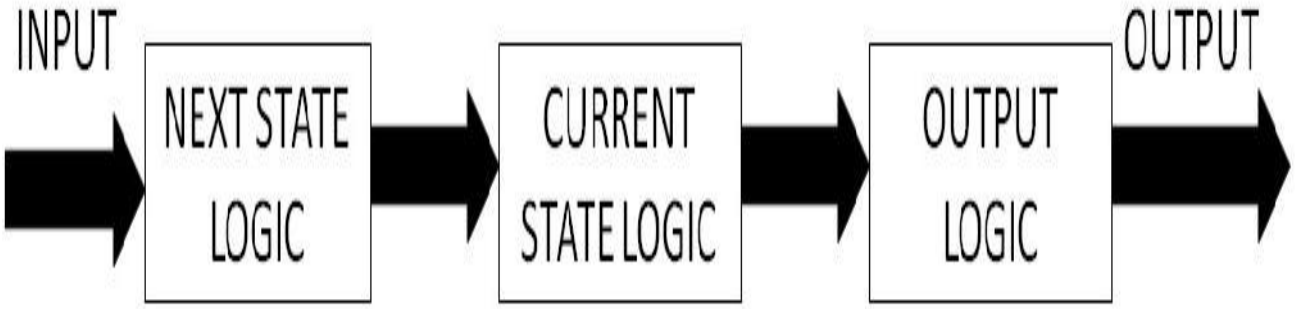

FIG. III MOORE MACHINE

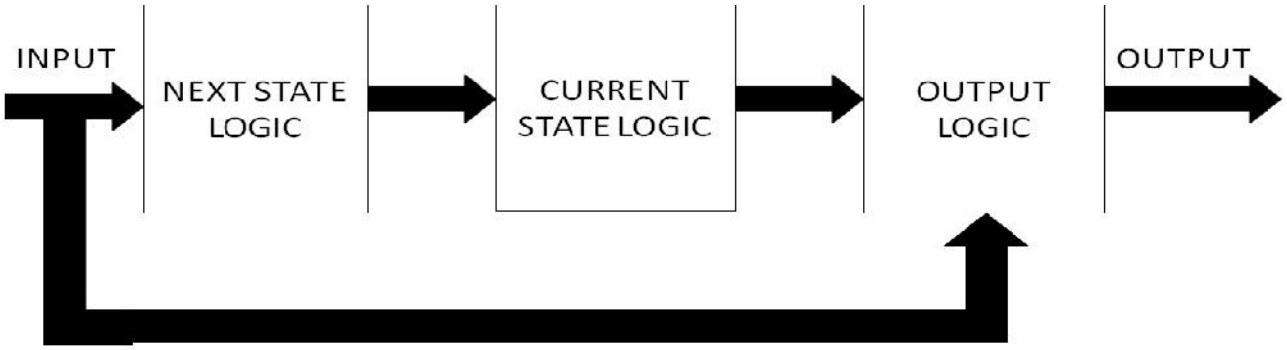

FIG. IV MEALY MACHINE

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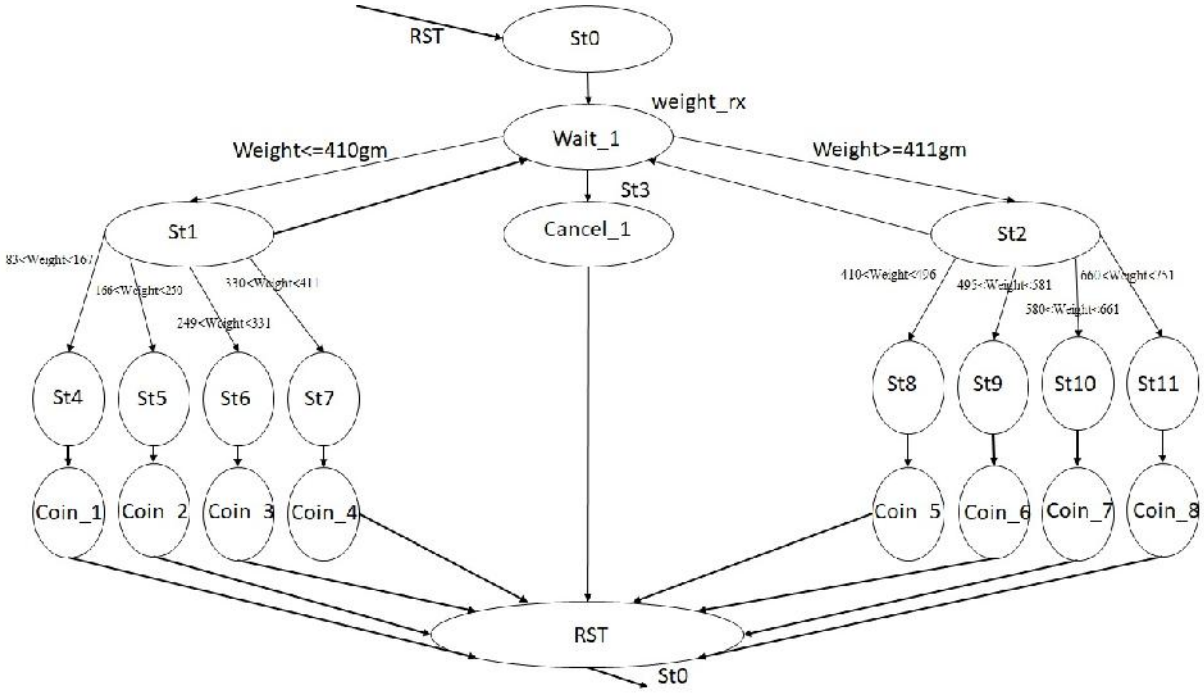
V. IMPLEMENTATION

Paper designed reverse vending machine in terms of state diagram. The user can get output in terms of coin that is depend on weight of the item received by machine. Description of output is explaining in Table I. The reverse vending machine can accept waste plastic material as an input.



A. *States Description*

The output of coins according to weight is shown in figure V. Where St0 is the initial state, St1, St2, St3 are input states and output states are St4, St5, St6, St7, St8, St9, St10 and St11. The weight_rx signal means the waste plastic material is received or not received by the reverse vending machine, if received than move for further tests. Cancel_1 is a button used to cancel the process at any stage or the no material is received or the item is not made up of plastic or item is filled with something. Hence the process is cancel by machine by its own [6]. There are two conditions one is when weight is less than 411gm then the reverse vending machine give coins (1,2,3,4) according to their weight and second is when weight is greater than 410gm then it will give coins (5,6,7,8) as output and explained properly in below table I.

Table I: Description of Coin_out

S.NO.	INPUT	OUTPUT
	Weight of Empty Container(gm)	Coins
1	84-166	1
2	167-249	2
3	250-330	3
4	331-410	4
5	411-495	5
6	496-580	6
7	581-660	7
8	661-750	8

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VI. IMPLEMENTATION OF BLOCK DIAGRAM

Register Transfer Level (RTL) is a view which we get after the simulation of program. It is a simple block representation of inputs and outputs or we can say that the logical operations of a circuit perform on digital signal or data between registers. It is a high-level representation of a proposed machine or circuits. In this RTL view has four inputs (weight_rx, weight, ck, rst) and two outputs (coin_out, coin_out1).

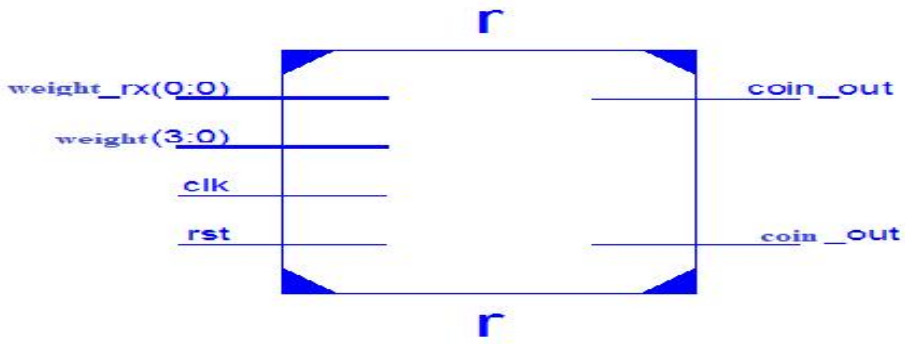

Fig. VI: Register Transfer Level(RTL) View

Technical Schematic view of reverse vending machine is a representation of the logic elements to proposed technology. It consists Input, Output buffers, carry logic, other components. In Table II, we show the number of flip-fops, input LUTs, Slices, bonded input/output are used. It is a report which create after design file.

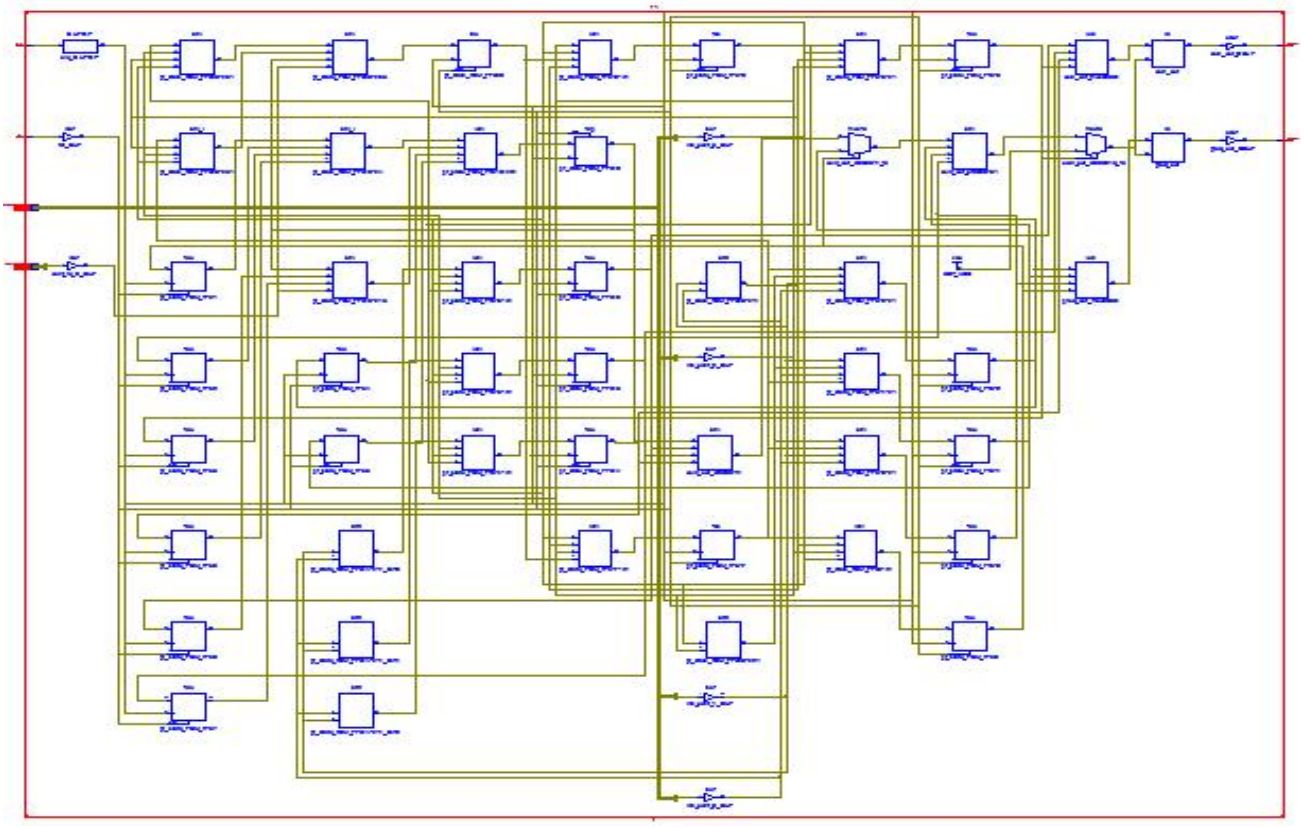

Fig. VII: Schematic View of RVM

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Table II : 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. RESULTS

The output of proposed reverse vending machine is shown in Figure VIIIth, IXth, Xth for different cases of user getting output. The simulation is done on Xilinx ISE simulator. In figure VIII, user insert waste plastic material of weight in range of 249gm to 331gm now it will move to St6 state from St1 state and give 3 coins as an output. Similarly, in figure IX, user insert waste plastic material of weight in range of 661gm to 750gm it will move to St11 state from St1 state and give 8 coins as an output. In figure X, no material is inserted by the user or non-ideal type material is inserted. So, the machine will move to cancel state.

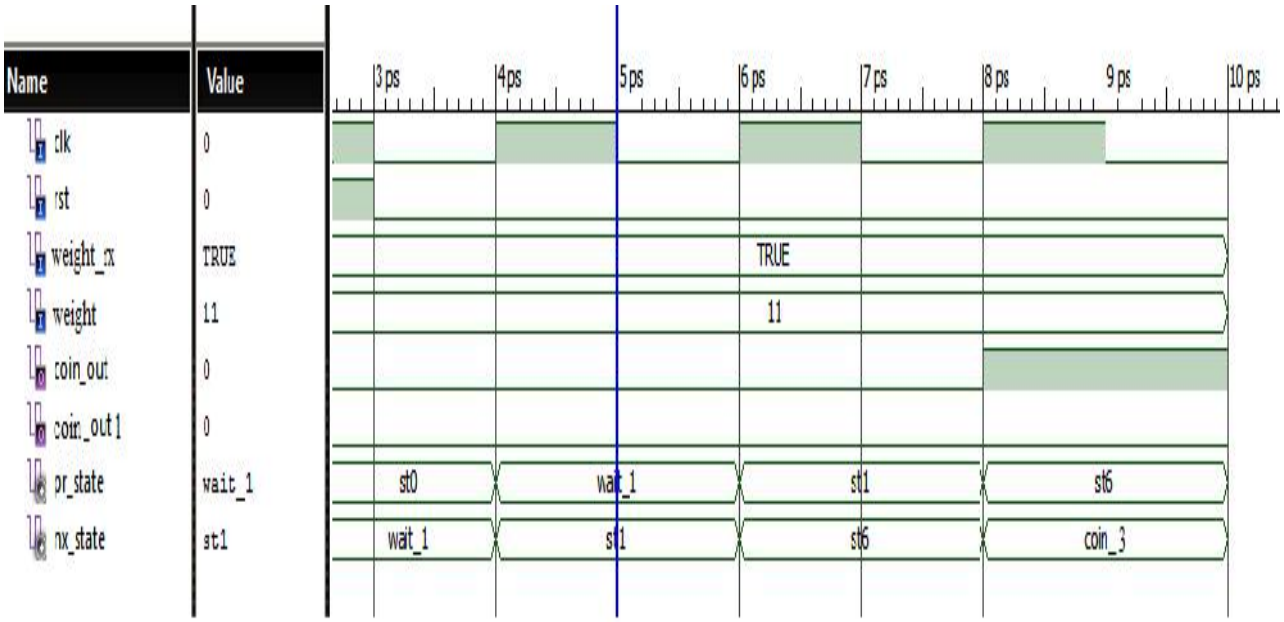

Fig. VIII: Simulation Results for waste plastic material weight 250-330gm

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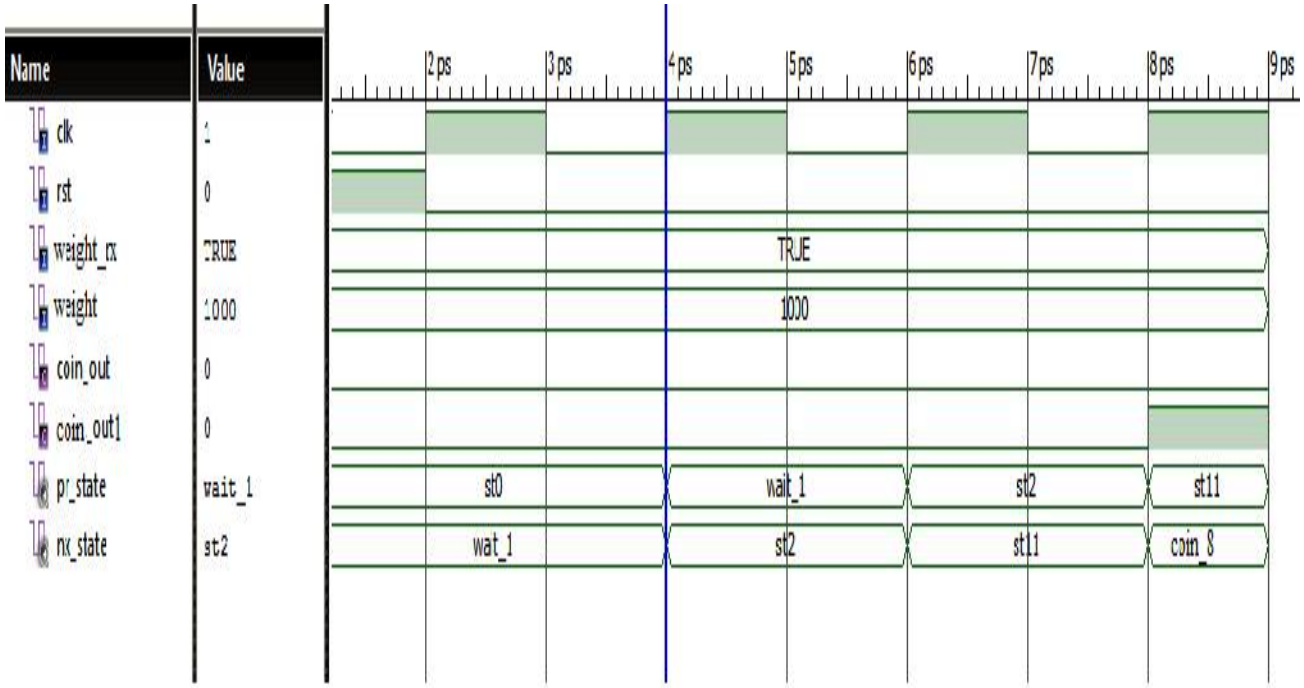

Fig. IX: Simulation Results for waste plastic material weight 661-750gm

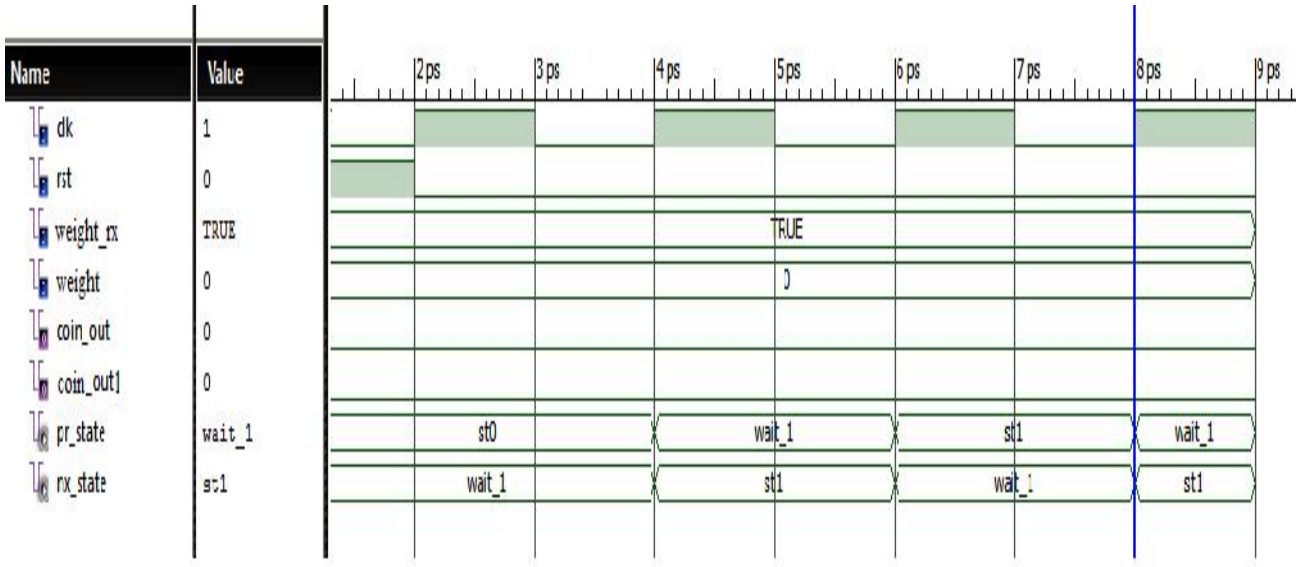

Fig. X: Simulation Results for no weight detected

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VIII. CONCLUSION

In this paper, a prototype of the Smart Plastic Recycle Machine is successfully simulated. Reverse Vending Machine is Simulated using Xilinx 14.5 ISE Simulator. User inputs plastic material into the system, the system enables the summation of points throughout the recycling process. The reward coins and weight of plastic increment with every input to the system. If the user inputs an invalid object or invalid type item into the system, system cannot except the input material and reset the system. The system will work efficiently and cost effective in implementing the design of creating the recycle machine's programmable hardware-based detection system using a capacitive proximity sensor, an infrared photoelectric sensor and strain gauge weight sensor which is readily available in the market and very cost efficient. The future scope of this proposed reverse vending machine is to implement whole system on hardware.

The challenges and scopes of this work are:

1) Improved detection accuracy of the sensor system

2) Sorting system for different materials

3) Redemption of reward points

4) Lower energy consumption

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