Front End Realization of Automatic Washing Machine

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ABSTRACT
Most of the washing machines today involve application of microcontrollers in order to perform various functions. The objective of this paper is to design an Application Specific IC (ASIC) for a washing machine. This ASIC will be used in the washing machines. The Very High Speed Integrated Circuit (VHSIC) Hardware Description Language (VHDL) has been used as the programming language. An ASIC is a customized integrated circuit. Implementation of analog circuit and mixed signal designs are possible in ASIC. It reduces the system cost, area, power consumption and also reduces the assembly and testing costs. It avoids the effects of components no longer being available. It gives design flexibility which helps in speed optimizations. ASIC requires fewer component hence reduces service/maintenance costs. It is more reliable.

KEYWORDS
ASIC, VHDL, hardware description language, micro-controller, signal, automatic washing machine.

1. INTRODUCTION
With better clothing came in the need for better washing, this led to invention of tools for washing, first washing machine was a broom with four claws at the bottom to move the clothes around a tub or a bucket. In modern days fully automated ones based on microcontroller, it's evident that washing machines have come a long way. Washing machines are gradually emerging as a ubiquitous *dhobi* in Indian homes. Today market is flooded with many models, each vaunting of a large number of features and specialties [2]. A washing machine is a machine to wash laundry, such as clothing and sheets. The word is mostly applied only to machines that use water as opposed to dry cleaning (which uses alternative cleaning fluids, and is performed by specialist businesses) or ultrasonic cleaners. Washing process comprises immersing, dipping, rubbing, or scrubbing in water usually accompanied by detergent, or bleach. The simplest machines may merely agitate clothes in water while switched on; automatic machines on the other hand may fill, empty, wash, spin, and heat in a cycle. Washing machines are of two types by function:

1. Semi Automatic: In semi-automatic machines the controls are not completely automatic and manual intervention is required. These are top loading twin tub machines where the washer and the dryer are separate units. So the task of loading and unloading a couple of extra times. These are preferable where running water is not available.

2. Fully Automatic: A fully automatic, on the other hand, can be either front or top loading and there is no manual intervention needed—drop the clothes, turn the machine on, and wait for it to finish washing and drying. Fully automatic machines require a dedicated running water supply from a tap. The whole process is carried out in a single tub. The washer, dominantly, would function almost entirely the same way it does now, but the clothes would be cleaned with a fluid other than water [4]. This would almost completely remove the need for water. The clothes are dropped in the tub, water and detergent is added, then wash cycle is programmed according to the requirement. The washing machine does washing, rising, and drying and notifies with beeps when it is through with all the tasks.

There is further classification of washing machines on the basis of how clothes are fed in to the machine. On this basis machines are divided into two types top loaded and front loaded.

1. Top loaded machine: Top loading machines use two vertical drums with an agitator to pull the clothes down in the center as it moves back and forth. The center then pushes them back up on the outside of the basket. This motion is repeated for a determined amount of time. The inside drum is able to move and is perforated so water can escape. The outer drum holds the water. Top loaders use much more water than the front loaders.

   Top loaders allow to removing the clothes easily, without having to bend, even during power failure. These machines are compact and require normal detergents for washing. Clothes can be added even if the wash cycle has begun. The larger the drum, the loading and the unloading is more convenient. [5].

2. Front loaded machine: Front-loading washing machines requires less water and energy, as compared to conventional machines. All front-loading machines use the tumble wash action for washing clothes. Front loaders are usually more expensive. However, these consume less water and dry clothes much faster than the top loading machine; thereby reduce the consumption of energy [1].

   Front loaders cannot be open midway through a wash cycle. This type of loader use detergents producing less lather and, if the power fails, door can't open due to water present in the drum [5]. The objective of this paper is to show the development of ASIC for a washing machine. As of now making of the IC specifically for washing machines and it is not used in other applications. Verification of the software code with the logical flowchart of the washing machine is done. The simulation results obtained are in

conformance with the logical flow of the working of fully automatic washing machine.

2. DESIGN OF AUTOMATIC WASHING MACHINE

2.1 Principle of automatic washing machine

The inside bucket of fully-automatic washing machine has many small holes, through them the water bucket between the inside and outside is interlinked, electromagnetic valve pumps the water in and out. When the water fills in the control system the electromagnetic valve opens up, this allows the water to be fed into outer barrel. During drainage, the control system lets the drain electromagnetic valve open up, so the water by outer barrel drains out. When dehydrating, the control system will close valve and by turning on washing motor driving internal vats to dry. High, middle and low water level control switches are used to detect the high, middle and low water level. Start button activates the washing machine; stop button is used to manually stop water, drainage, dehydration and alarm. Drainage button is to achieve manual drainage [3].

2.2 Working of automatic washing machine

As discussed earlier there are two types of washing machines, the top loader and the front loader. With either machine it is filled with clothing or other linens, some detergent is added and it turns on. They are directly hooked to water lines which bring water into the drum and mixes with the detergent. Then they agitate or bounce the clothing through the soapy water, thereby cleaning out the dirt and soil. The machines go into a spin cycle and pull all the water back out of the clothing. Once more, water fills the tub and rinses out the remaining soap. Again, with high speed spinning it spins out the water and leaves the clothes dried [1]. The functional block diagram of a washing machine is shown below in fig 1.

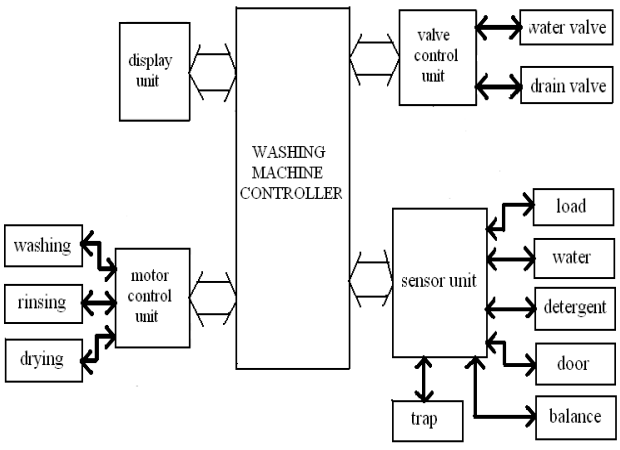

Fig. 1. Block diagram of automatic washing machine

In the above figure there are units which are controlled by a controller. These units are described below:

1. Valve control unit: This unit control the water inlet valve and drain valve. It contains all the information about the water valve, such as when it open and close. Similarily, it contains all the information about the opening and closing of drain valve.

2. Sensor unit: Sensor unit contains all the information of the sensors which are used in washing machine, such as, sensor for load check(clothes weight) gives the information that how much load is present inside the tub accordingly water fills into the tub. Similarily, it contains information for all other sensors required in washing machine, such as, water availability check, detergent availability, door open/close, balance check and trap check.

3. Motor control unit: This unit controls the functioning of motor. It contains all the information about the rotation of motor, such as when motor rotates in clockwise direction and when in counter clockwise. It also contains the information when motor will on and off in all three cases i.e., washing, rinsing and drying.

4. Display unit: The display unit consist of LEDs to indicate the completion of process, occurrence of some problem while washing, set or reset of buttons, etc. Seven segment display for the numeric value display and also for the messege display of errors.

2.3 Washing technique

There are two washing techniques used in washing machine. One of the technique is widely used in top loaded washing machine and the other is used in front loaded washing machine or say fully automatic washing machine. These techniques are explained below:

1. Agitator wash technique: In this technique, a rod with fin is used at the centre of the washing machine. A rubbing action of an agitator squeezes the dirt out of clothes. But it restricts the space and the clothes tend to get entangled. This technique is used in top loaded washing machine [5], [6]. The spinning requirements on vertical axis washers are much less so this part of the control is reasonably simple. However the agitation phase requirements are more complicated to achieve [7].

2. Tumble wash technique: This technique is used in front loading washing machine. This type of machine contains steel drum. This drum rotates along a horizontal axis and the clothes present inside the tub rub against its metal surface due to centrifugal action. The cleaning done by this technique is superior but there is a risk of ruining gentle fabrics [5], [6]. During the tumble action, the motor runs at low rpm clockwise and counter clockwise with a very high torque requirement. During the spin the motor is always in field weakening, so the motor works always very far from its nominal speed [7].

3. WORKING MODULES OF WASHING MACHINE

For building up the IC we have broken down the working of washing machine in modules. Below there is a modular breakdown with flow chart for each module:

3.1 Washing module

1. To begin with the wash process it needs to be check if the water is available for washing from the water supply into the machine or not, if the water supply is feeding in water into the machine properly then the process advances further.

2. After validating the water supply move on to detergent check in the detergent container. If detergent is available for washing, the process continues. If for some reason the detergent is not present in the detergent container then it needs to be added.

3. As next part of the process, water is filled in the drum for specific duration, after that water valve closes. This is done in order to prevent any overflowing of water in machine, as it can lead to inefficient washing and damage to the machine parts.

4. The drum of the machine needs to rotate in order to perform the wash action. For this purpose the motor starts which in turn rotates the washing drum, and stops after specific time once the wash process is completed.

5. Once the wash process is completed the water is drained out. The drainage of water is essential as there is a need to feed in fresh water for the next module i.e. rinsing.

The above steps have been illustrated in the following flow chart in fig.2.

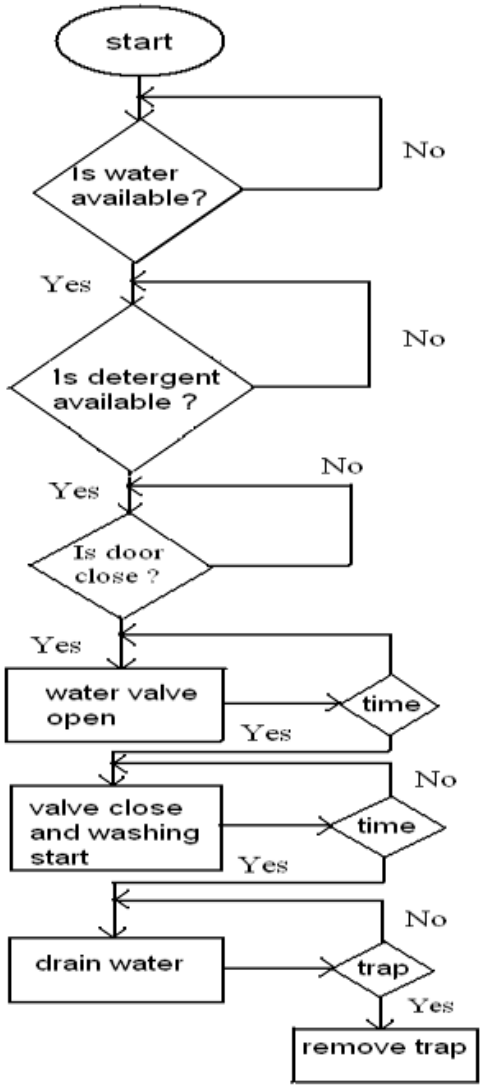

Fig. 2. Flowchart of washing module

3.2 Rinsing module

1. To begin with the rinse process again it needs to be check if the water is available for rinsing or not, if the water supply is feeding in water into the machine properly then the process advances further.

2. The door of the machine needs to be checked if it's properly closed. If the door is not closed it can lead to leakage of water from the machine. If the door is found to be closed then process moves further.

3. As next part of the process, after water is filled in the drum for specific duration, water valve closes. This is done in order to prevent any overflowing of water in machine.

4. The drum of the machine needs to rotate in order to perform the rinse action. For this purpose the motor starts which in turn rotates the drum, and stops after specific time.

5. Once the rinse process is completed the water is drained out. The drainage of water is essential as need to remove all the remaining dirt on clothes, so that the process can move further to the next module i.e. drying.
6. In the end it needs to be checked that there should be no trap in the drain pipe. If found it has to be removed as a trap or blockage in the drain pipe can lead to water logging inside the machine.

The above steps have been illustrated in the following flow chart in fig.3.

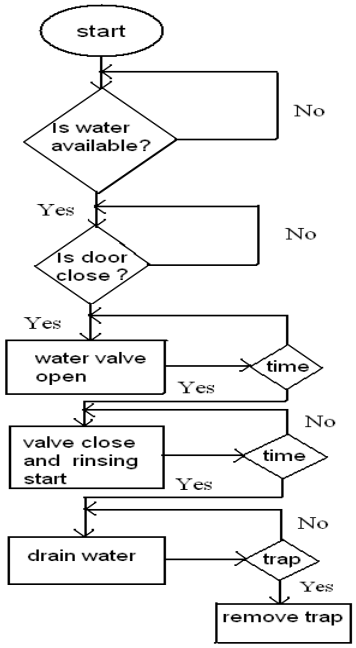

Fig. 3. Flowchart of rinsing module

3.3 Drying module

1. After the rinsing has been done, to start with drying process it needs to be checked if the door is closed. This is an obvious check as if the door is not closed it can lead to leakage of water from the machine. If the door is found to be closed then process moves further.
2. The drum of the machine needs to rotate in order to perform the drying action. For this purpose the motor start which in turn rotates the drum in single direction either clockwise or counter clockwise, and at the same time drain valve is also open so that water drains out through the drain pipe, and the process stops after specific time once the clothes have dried out properly.

   Higher the spins speed, the dryer the clothes at the end of the washing cycle and hence the shorter the drying time. Thus a high spin speed results in less washing time.
3. When the water drains out completely from the laundry the buzzer beep to indicate that the drying process is completed. Hence the whole washing process is completed.
4. In the end, when the buzzer beeps, switch off the power supply and the dried clothes can be taken out of the machine.

The above steps have been illustrated in the following flow chart in fig.4

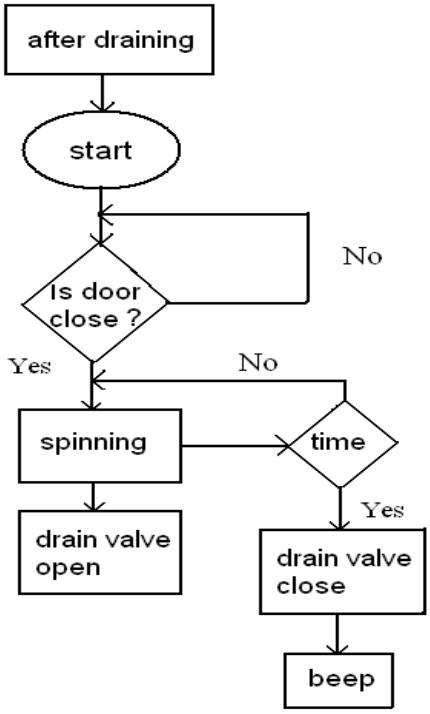

Fig. 4. Flowchart of drying module

4. SIMULATION RESULTS

The software has been developed in Xilinx tool and the simulations also have been obtained by the same tool. In this software code lot of input and output signals have been used. In the below table, description of the input/output pins used in software code are given which is followed by the RTL (Resistor Transfer Logic) view and simulation result for the working of washing machine.

Table 1. Pins description of washing machine controller

Input signal	**Description**
Clk	System clock
Re	Reset input
Imb	Tub balance check
s1<1:0>	Spin (rpm)
Wa	Water check
Wt	Weight on drain valve

Det	Detergent check
Output signal	**Description**
output,output1,output 2	Additional clock of different time period as compared to system clock
w <4:0>	Door close, water valve open or close [washing]
w1<4:0>	Motor start or close [washing]
w11<4:0>	Drain valve open or close [washing]
r <4:0>	Door close, water valve open or close [rinsing]
r1 <4:0>	Motor start or close [rinsing]
r11 <4:0>	Drain valve open or close [rinsing]
dry <4:0>	Motor start or close [drying]
Beep	Indicates the process completion

The RTL view for the IC on the basis of the VHDL code has been obtained. The RTL view is shown below in fig.5

This RTL view gives the pictorial view of IC pins. All the pins on the right side are the output pins and all pins on the left side are the input pins. The descriptions of the I/O pins are given in table. 1. How many I/O pins will be present in the IC? It can be easily counted from the fig. 5. After the synthesis of VHDL code, test bench for the same is to be drawn, set the values of all inputs in the form (0 or 1) accordingly then simulate the test bench to get the simulation results. Simulation results give the output in the form (0 or 1) with respect to the set inputs. When reset signal is on, all of the signals set zeros; then if the start button is on, the machine will enter in water filling state for washing. As long as washing process is not completed, washing machine will automatically execute the process according to the predetermined. After the completion of whole washing process buzzer beep. The simulation results as shown in fig.6

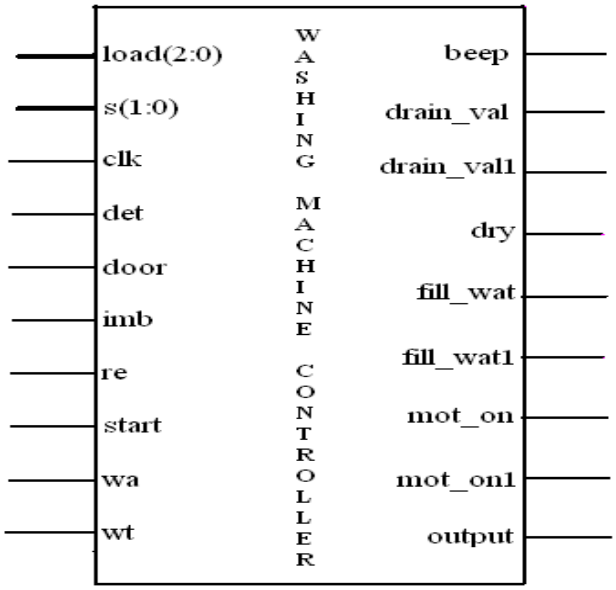

Fig. 5. RTL view of washing machine controller

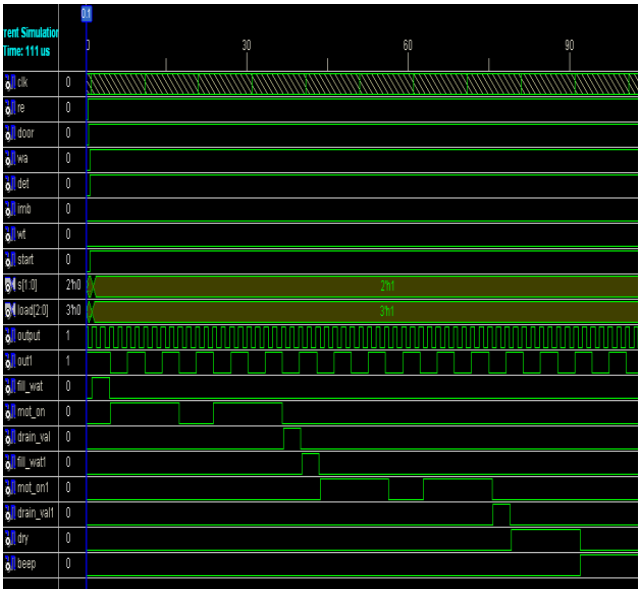

Fig. 6. Flowchart of washing module

5. FUTURE WORK

As of now the project code has been written and verified keeping in mind the modular breakdown of three processes i.e. washing, rinsing and drying. The simulations generated confirm the expected results of the code. Moving on from here, aim is towards realizing the schematic generation of the ASIC with the help of Cadence. After the schematic has been generated the next advancement in the project will be to obtain the layout, symbol and post layout simulation for the IC. After the layout generation, need to embed the ASIC into the test circuit bed and check the working of the circuit. If the results are found to be satisfactory

the last process would be optimization of the ASIC in order to be viable for practical use.

6. CONCLUSION

In this paper software designing of an IC for a fully automatic washing machine is done. The type of machine taken into consideration is front loaded washing machine. The aim of this research is to replace the microcontroller with ASIC which could reduce the board area and number of peripherals. The software code for the IC has been completed using VHDL. The simulation results confirm the expected working of the code. The next step would be to obtain the schematic using Cadence and then form the layout for the IC.

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8. REFERENCES

[1] Basic model WF-F1061 service manual Samsung Electronics Co., Ltd. April. 2006

[2] Ms. Lei Lei Yin Win, Ms. Phyu Hnin Khaing, Dr. Mg Mg Latt, "Design Considerations for Microcontroller Based Process Control for Washing Machine", International Conference on Digital Image Processing, 2009

[3] Chen Xizhen, Chen Guangjian, Jia Jinling, Yu Han, Zhou Tianpeng, "Design of Automatic Washing Machine Based on Verilog HDL Language", International Conference on Electronics and Optoelectronics (ICEOE 2011)

[4] Andrew Dunn, Jeremy Kohlitz, Keqin Cao, Mingming Yang, "Whirlpool Duet Washing Machine Water Recycling and Reduction Project", April 15, 2008

[5] R. Narayanan, Buyer's Guide (EFY), "Fuzzy Logic Washing Machines", December 2003

[6] Discussion report: "EU Ecolabel for Washing Machines", AEA group, September 2009

[7] Andrea Bianchi, Massimo Valiani, "DSP-based versus Microcontroller-based Variable Frequency Drives for Domestic Washing Machines"