Power Optimised Mixing Tank Using Approximate Computing and Adaptive Voltage Level at Supply

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***Abstract*—In the last couple of decades, there has been a tremendous advancement in the size and speed of electronic components like logic gates and Integrated Circuit chips. Density of transistors on microchips have been increasing exponentially as expected by Moore's Law. But as we come nearer to where we are now, it is quite uncertain as to how further progress can be made.[5] Putting this technology to use ,lots of hazardous applications like Chemical Mixing , furnace tapping and manufacturing of harmful drugs can be automatised enhancing the efficiency of process and also making the process less vulnerable to failure.**

***Index Terms*—Ngspice, Approximate Computing ,Adaptive Voltage at Supply, Complimentary metal oxide semiconductor(CMOS)**

I. Introduction

In almost every manufacturing industry, 'chemical mixing' is one of the most crucial stages and also the most influential to the final outcome. Automatizing of this process can be done in many ways but coming up with an efficient and Less power consuming way has always been a challenge. As there has been a huge boom in the electronics sector, faster and more efficient CMOS and TTL gates allow new mixing technologies to guarantee shorter production time and enhance the final outcome.

In the recent times the amount of functionality on a single chip has grown immensely, but still there is a need to reduce the power consumption by the SoC to avoid high electric fields effects on the circuit.[4] Making low power devices also prevent overheating thus making them long lasting.

Earlier power consumption of CMOS devices was not a concern while designing chips instead Factors like speed and area predominated the design parameters. As the CMOS technology moved below sub-micron levels the power consumption per unit area of the chip has risen tremendously. Few flourishing Methods like Approximate computing and Adaptive voltage at supply can be implemented to make a low power circuit.[4]

In this paper , we will focus on how a highly custom-built low cost energy efficient chemical mixing industrial tank and simulate the results of same in Multisim and Ngspice.

II. Chemical Mixing Tank

A. Components Used

In this Chemical Mixing model , we will be using

- Op-Amp
- RS Flip-Flops
- CMOS Transistors
- Relay
- Resistors
- Capacitors
- And/OR/NOT logic gates
- AC DC voltage Supply
- Switches

B. Working and Construction

The Basic Construction of a Chemical Mixing tank Involves two Sensors namely **S1** and **S2**. Sensor S1 is present at the bottom of the tank and Sensor two at the Limiting Height of the tank. Two or more valves are present at the top of the tank that allow the flow of chemicals in the Mixing Tank. A Stirrer Ac Motor connected to a shaft is present at the top of the Mixing container which turns on when the chemical liquid level reaches the at the Limiting height corresponding to Sensor **S2**. The Chemicals from the valves enter when the Mixing tank till the liquid level reaches the top of the tank, then mixing by the Stirring motor takes place for **t** seconds followed by opening of the output valve till the chemical level goes below Sensor **S1** . The Same process is repeated Indefinitely.

555 IC is Constructed Using op-amp (as Comparators) , SR flip-flop and transistors.

SR flip flop consists of **AND** gates and **OR** gates. These and Gates can either consist of PN junction Transistors or CMOS transistors.

A Relay is used at the output which signals the motor to switch on or off depending on the digital HIGH or LOW it receives.

C. Design of the Chemical Mixing Circuit

III. Making the Mixing Tank System Low power

The current Circuit works just fine , but few alterations in the circuit components can help us achieve a more efficient

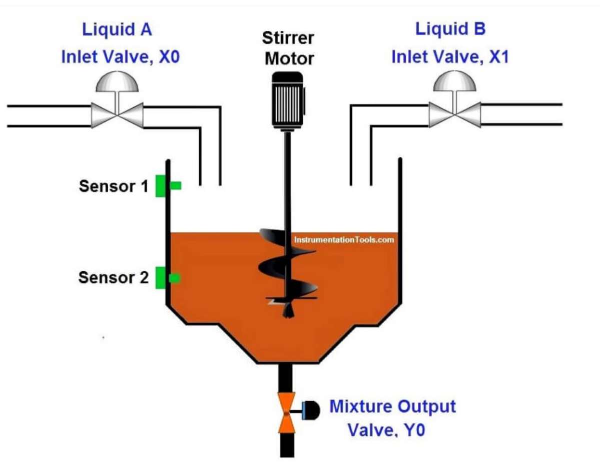

Fig. 1. Working of a Basic Chemical Mixing Machine

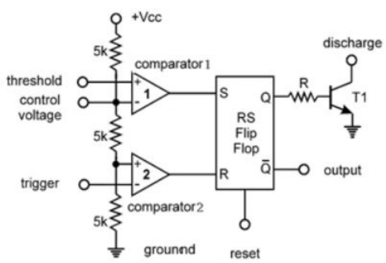

Fig. 2. 555 IC Internal Architecture

and less power consuming system.

We can Implement the following Methods in the Logic gates to reduce the power consumption.

- Adaptive Voltage Level at Supply
- Approximate Computing

A. Adaptive Voltage Level at supply

Unlike a normal CMOS circuit ,this novel electronic component decreases the voltage level at the point where the CMOS circuit starts. This novel circuit works on pull-up and

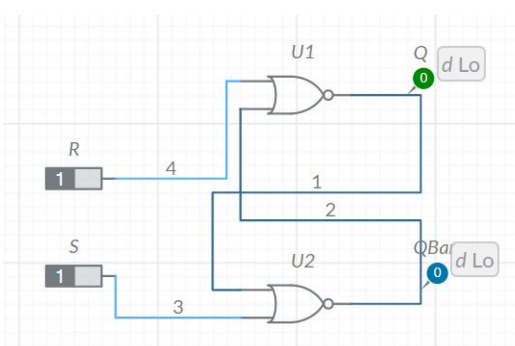

Fig. 3. S R Flip Flop

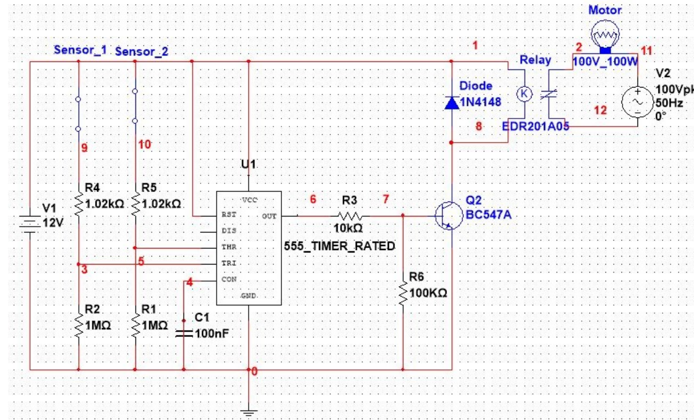

Fig. 4. Chemical Mixing Circuit Enabling Motor

push=down network mechanism. Our main motive in this circuit is to reduce the leakage current as much as possible so we get maximum Vcc in our active state. Leakage current is a combination of

- Reverse Bias current
- Gate induced current
- sub threshold leakage current

This novel adaptive voltage level at supply CMOS circuit functions like a voltage divider circuit during the clocking process. The potential in the circuit is directly proportional to the current in the circuit which is in tern directly proportional to the clocking process.[2] Same Inputs and same clock rate are given to the OLD CMOS gates and the new gates and the power is calculated. calculation of power and the clock is also kept of a constant frequency In this Technology we save static Power

Below are the comparison between a normal CMOS AND gate and AVLS AND gate
Static Power = Total Power - Dynamic Power

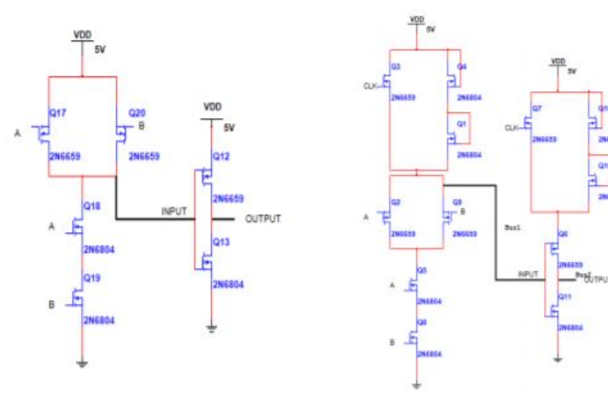

Fig. 5. Modified CMOS "AND" GATE

TABLE I
LEAKAGE POWER DISSIPATION FOR VARIOUS GATES

Sr. No.	GATE	Leakage Current (in uW)
1	CMOS NOT GATE	6.201063
2	AVLS NOT GATE	4.307817
3	CMOS AND GATE	0.176512
4	AVLS AND GATE	0.170371
5	CMOS OR GATE	0.587921
6	AVLS OR GATE	0.295814

B. Approximate Computing

Just like how us humans can extrapolate information using some sequence of data and fill in missing gaps, in Approximate Computing certain calculations which do not required absolute accuracy are approximated which intern leads to doubling the efficiency of the circuit as well as reducing the net power consumption of the circuit
As a result one can save power and area using Approximate computing if Absolute accuracy is not desired. Generally power dissipation in CMOS circuits occurs if there is a path between the supply and the ground through which the current can flow.

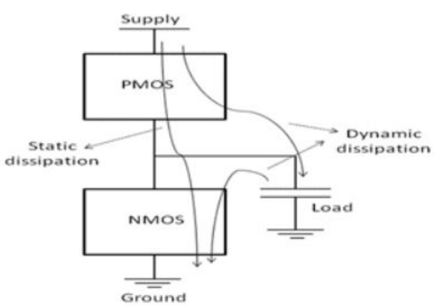

Fig. 6. Static and Dynamic power dissipation path

The design of Approximate NAND gate is made while keeping in mind the smallest path formed between the input and ground.
There is always a path that exists from the supply to ground and is a source of power dissipation for any combination of inputs.In this type of Architectue the total static power decipation will be less than the standard CMOS NAND gate

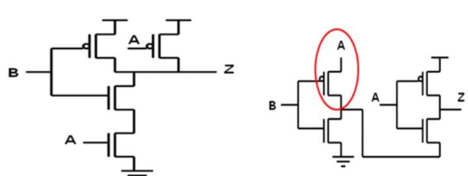

Fig. 7. Old CMOS vs NEW PROPOSED CMOS

The low power architecture proposed for approximate computing technique for NAND gate will reduce heat gradient which intern will reduce the mechanical stress on the circuit . The heat gradient across the chip can cause mechanical stress leading to early breakdown, worsening the reliability of the SoC and hence more and more attention will be focused on low power design techniques. Since, the proposed architecture of universal gates like NAND and NOR has been discussed which could be further taken as a base and other needed several other logic functionalities can be implemented.

C. Result of Approximate computing

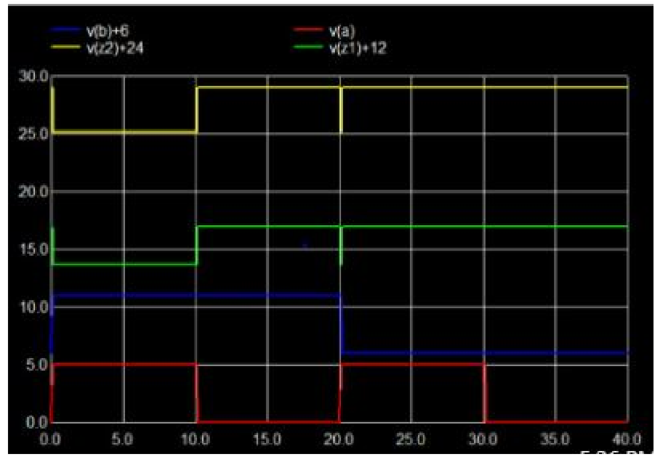

Fig. 8. Red – input1 , Blue – input2 , Green – Old CMOS , Yellow – New CMOS

IV. FINAL OUTPUT OF WATER TANK CIRCUIT

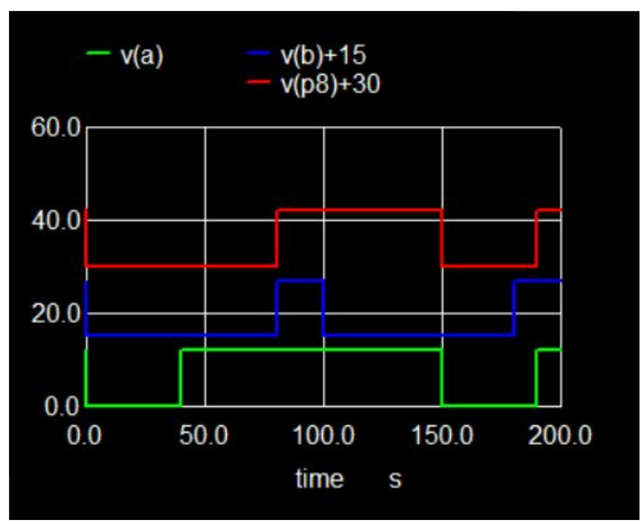

Fig. 9. Green – Sensor1 , blue – Sensor2 , Red – Output valve

A. Conclusion

Initially the Tank is empty and so s1 and s2 both give us LOW logic. As the tank starts filling S1 will give high where as S2 will still signal low As the liquid fills to the brim, both s1 and s2 will give us logic high and at this case we will stop the input valve and wait for a few minutes where the Tank Stirring motor will be turned on . Next the output Valve will be opened and the liquid level inside the Tank will decrease till the point when Sensor1 gives LOW. This process will go on Indefinitely

Later We Studied Two Methods namely Adaptive Voltage level at supply and Approximate Computing to Reducing the Total Power Consumption results of which were simulated on Ngspice

V. Acknowledgement

I would like to thank VNIT to provide me with an opportunity to study the subject Device Modeling and give me a chance to present my idea in the form of a Project and simulate the results on NgSpice. I would also like to thank Dr. Ganesh Patil and Mr. Mohan Sardar for guiding me and enhancing my knowledge in the field of Device Modeling.

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