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Low Power Multivibrator circuits using Subthreshold Adiabatic Logic

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***Abstract*— A Multivibrator is an electronic circuit which is used to implement a variety of two-state systems such as oscillators, timers and flip-flops. These multivibrators find applications in a variety of systems where timed intervals or square waves are required. For example, before the emergence of low-cost integrated circuits, chains of multivibrators were used as frequency dividers. This paper presents various types of multivibrator circuits i.e. Monostable, Bistable and Astable that dissipates less power. These multivibrator circuits were implemented using subthreshold adiabatic logic. In this paper the results are verified using 0.18µm CMOS standard process technology.**

Keywords— Multivibrators, Subthreshold Adiabatic logic, Flip-flop, Power dissipation

I. INTRODUCTION

To reduce the power consumption, the two existing low-power technologies to be considered are Sub-threshold CMOS and Adiabatic logic. Sub-threshold CMOS theory is a technique which can reduce the power consumption to lower than threshold voltage specified and Adiabatic logic circuit is a technique to reduce energy consumption by suppressing the voltage applied to the resistance of the circuit [1].

Multivibrator is characterized by two amplifying devices which are cross-coupled by resistors or capacitors arranged with regenerative feedback [5]. Multivibrator is an electronic circuit that works as two stage amplifier operating in both stable and astable mode. They have two different electrical states, an output "1" state and an output "0" state giving them either a stable or quasi-stable state depending upon the type of multivibrator. Depending on the circuit operation there are three types of multivibrator circuits: Astable Multivibrator, Monostable Multivibrator and Bistable Multivibrator. The remainder of this paper is divided into four sections. Section 2 describes the proposed subthreshold adiabatic logic circuits. In Section 3, the structure and operation of multivibrator circuits are explained. Section 4 describes the simulation of multivibrators and also provides a comparison between the power dissipations of multivibrators generated using subthreshold adiabatic logic and CMOS logic.

II. SUBTHRESHOLD ADIABATIC LOGIC

The proposed system (Two Phase Clocking Subthreshold Adiabatic Logic, [1]) uses a two phase clocking power supply which has different frequency and amplitude. For example a 2-chain inverter circuit is shown in fig. 1. The timing chart for the circuit is shown in fig. 2. It is necessary to switch on-off the input signal when V_{PC} and $V_{\overline{PC}}$. The frequency of $V_{\overline{PC}}$ is twice, based on the frequency of V_{PC}, and the input signal frequency is 1/2. The amplitude of V_{PC} and $V_{\overline{PC}}$ are 0-0.5V and 0–0.25V respectively. The frequencies of V_{PC} and $V_{\overline{PC}}$ are 10kHz and 20kHz. In period of T2, T4, T6 and T8, the voltage of these power supplies is low level and therefore, the outputs are always low-level; this means these timing become read protection period.

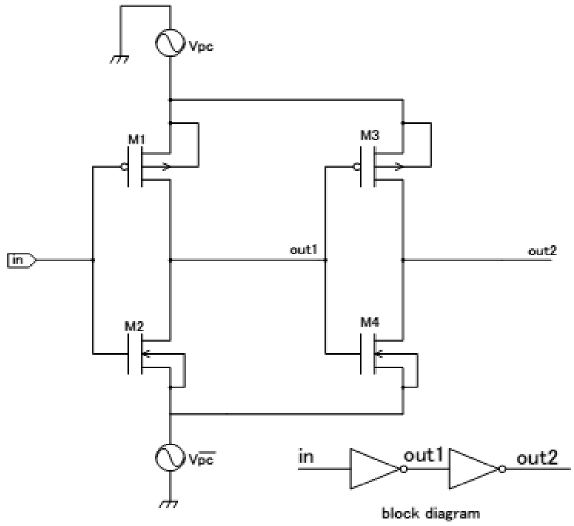

Fig.1. Cascaded inverter

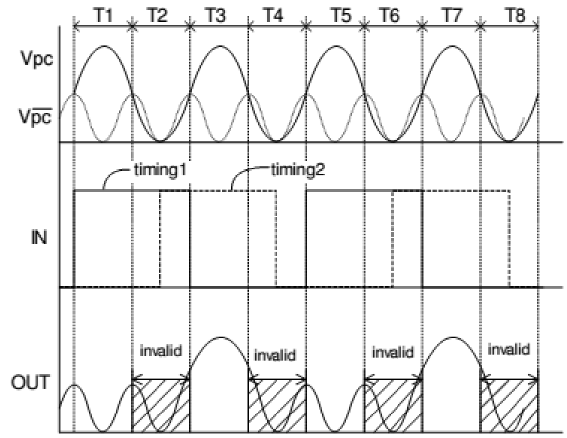

Fig.2. Timing chart

III. Multivibrators

A. Astable Multivibrator

The most commonly used type of multivibrator circuits are Astable Multivibrators . It is a free running oscillator that has no permanent steady state but is continually changing their output from one state to the other state and then back again. This continual switching action from “1” to “0” and “0” to “1” produces a stable and continuous square wave output that switches abruptly between the two logic levels making it ideal for timing and clock pulse applications. Astable Multivibrator can function as a relaxation oscillator.

The timing cycle can be determined by the RC time constant of the resistor-capacitor that is RC network. Then the frequency of the output can be varied by changing the value of the resistors and capacitor in the circuit.

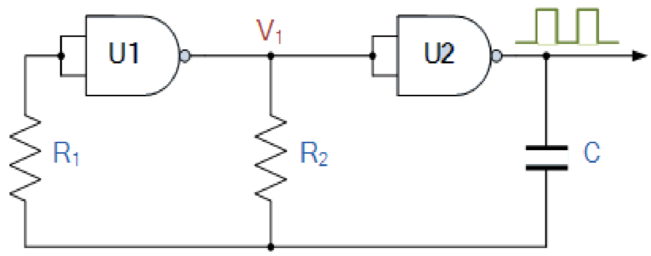

Fig. 3. Circuit for Astable Multivibrator

The astable multivibrator circuit uses RC timing network and a pair of CMOS NAND gates [6]. The NAND gates are connected as inverting NOT gates as shown in figure 3.

Suppose that the output from the NAND gate U2 is initially at logic level “1”, (principles of NAND gate), then the input must therefore be at logic level “0” as it will be the output from the first NAND gate U1.The Capacitor, C is connected in between the input of the second NAND gate U2 via the timing resistor, R_2 and its output. This makes the capacitor to charge up at a rate determined by the time constant of R_2 and C. As it charges up, the junction between the capacitor C and resistor R_2, which is also connected to the input of the NAND gate U1 via the resistor R_2, decreases until the lower threshold value of U1 is reached, at that point U1 changes its state and the output of U1 now becomes “1”. This causes the NAND gate U2 to change the state as its input has now changed from logic “0” to logic “1” resulting in the output of NAND gate U2 becoming logic level “0”.

Capacitor C is now reverse biased and the discharging takes place through the input of NAND gate U1. Capacitor, C again charges up in the opposite direction determined by the time constant of R_2 and C as before until it reaches the upper threshold value of NAND gate U1. This causes U1 to change its state and the cycle repeats again.

The time constant for Astable Multivibrator using NAND gates is given as T = 2.2RC (seconds) with the output frequency given as f = 1/T.

B. Monostable Multivibrator

Monostable Multivibrators have only one stable state and single output pulse is produced when triggered externally. In this type one state is stable and the other state is unstable (transient). A trigger pulse causes the circuit to enter the transient state. After entering the unstable state, the circuit will return to its first original and stable state after a time period determined by the RC circuit. Such a circuit is capable for creating a time period of fixed duration in response to some external occurrence. The monostable circuit is also known as ‘one shot’.

All monostable multivibrators are *timed* devices [3]. That is, their unstable output state will hold only for a certain minimum amount of time before returning to its stable state. With semiconductor monostable circuits, this timing function is typically accomplished through the use of resistors and capacitors, making use of the exponential charging rates of RC circuits.

Monostable circuits can be constructed using integrated circuits. The circuit shown below in fig.4 is a basic monostable multivibrator circuit which is constructed using two 2-input ‘NOR’ Gates [6].

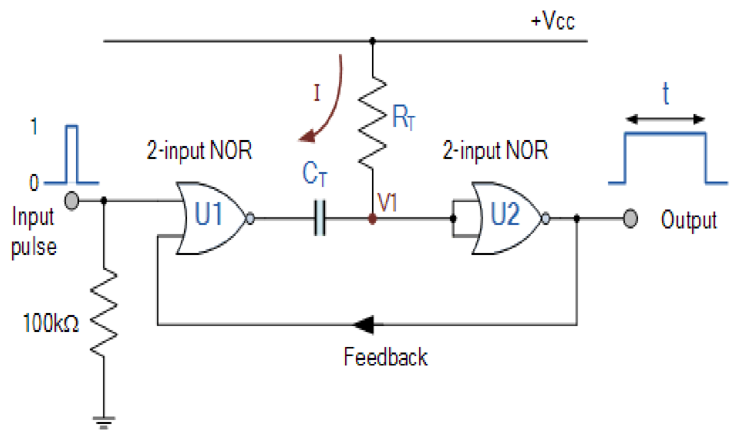

Fig. 4. Circuit for Monostable Multivibrator

Suppose that initially the trigger input is at logic level “0” so that the output from the first NOR gate U1 is at logic level “1”, (principles of NOR gate). The resistor, R_T is connected to the power supply voltage which is equal to logic level “1”, which means that the capacitor, C_T has same charge on both of its plates. Hence junction V1 is equal to this voltage so that the output from the second NOR gate U2 will be at logic level “0” representing the circuits “Stable State” with zero output.

At time t_0, when a positive trigger pulse is applied to the input the output of the first NOR gate U1goes LOW taking the left hand plate of capacitor C_T thereby discharging the capacitor. Now as the plates of the capacitor are at logic “0”, it is the input to the second gate, U2 resulting in an output equal to logic “1”. This second state represents the “Unstable State” with an output voltage equal to +Vcc.

The second gate, U2 maintains the unstable state until the timing capacitor charges up through resistor, R_T reaches the minimum input threshold voltage of U2 causing it to change the state as a logic level “1”. This makes the output to be reset to logic “0” which in turn is fed back (feedback loop) to one input of U2. This automatically returns the monostable multivibrator back to its original stable state and awaiting a second trigger pulse to restart the timing process once again.

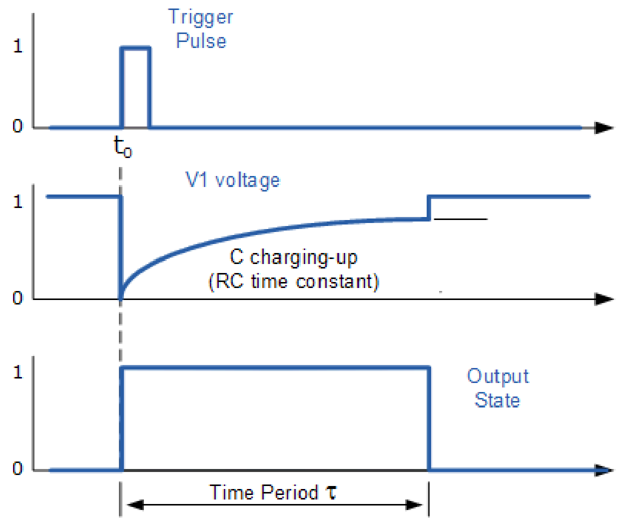

Fig.5. Timing waveform for Monostable Multivibrator

C. Bistable Multivibrator

It is another type of two state device similar to the Monostable Multivibrator. The Bistable Multivibrators have two stable states and indefinitely maintains a given output state. It will not change its state unless an external trigger is applied to it. By the application of an external trigger pulse the bistable multivibrator can be flipped over from one stable state to the other thus two external trigger pulses are required before it returns back to its original state. They are known as Latches and Flip-flops as they have two stable states.

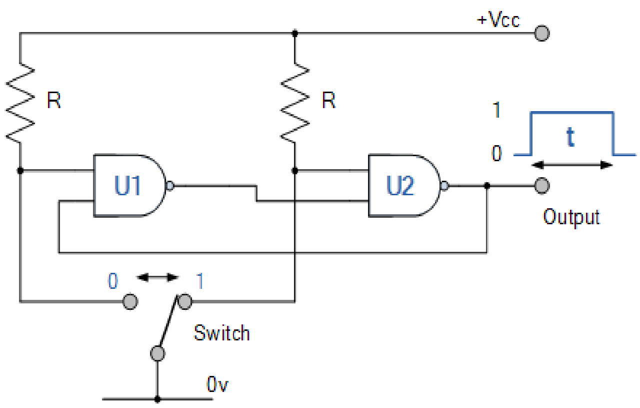

Fig.6. Circuit for Bistable Multivibrator

The bistable multivibrator circuit can be constructed using two NAND gates which are connected together as shown in fig. 6. This type of bistable circuit is also known as a “Bistable Flip-flop”. This bistable multivibrator is activated by the single-pole double-throw switch (SPDT) to produce a HIGH, logic “1” or a LOW, logic “0” signal at the output. This type of bistable switching circuit is commonly called a SR Flip-flop (using NAND Gates) [6] . The applications of these multivibrators include a set-reset, SR flip-flop circuit for use in counting circuits, or as a one-bit memory storage device. These bistable flip-flops can also be used as frequency dividers because the output pulses have a frequency that are exactly one half ($f/2$) that of the trigger input pulse frequency.

For sample waveforms of these multivibrators we can refer oscillators in [2]

IV. Results

These circuits were implemented and tested in HSPICE [4]. The results are obtained by simulating the code. Power dissipation is tabulated. It is shown in Table I.

Simulation Results:

A. Astable Multivibrator

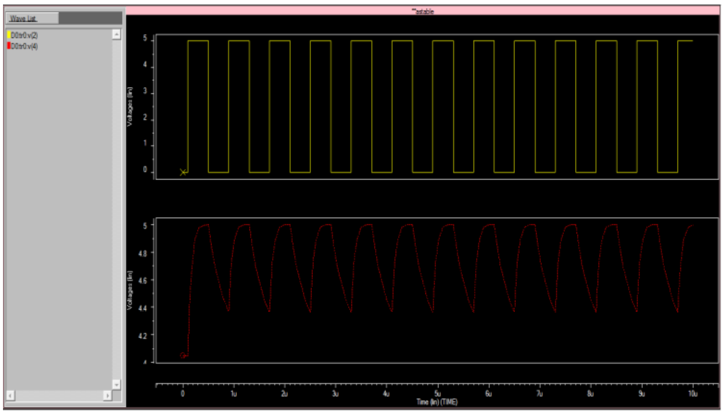

Fig.7. Astable Multivibrator using CMOS logic

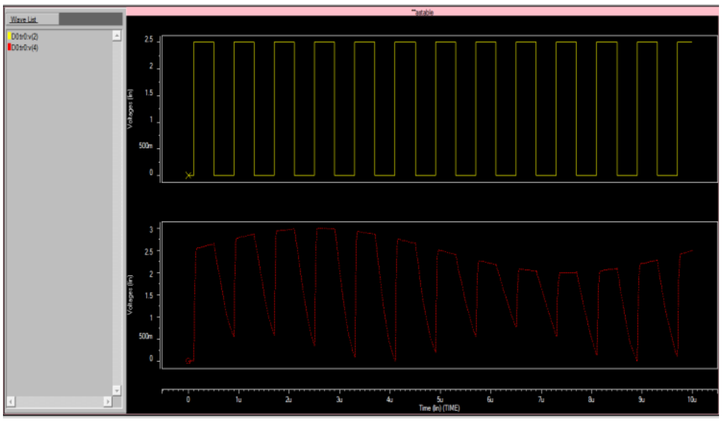

Fig. 8. Astable Multivibrator using Subthreshold Adiabatic logic

B. Monostable Multivibrator

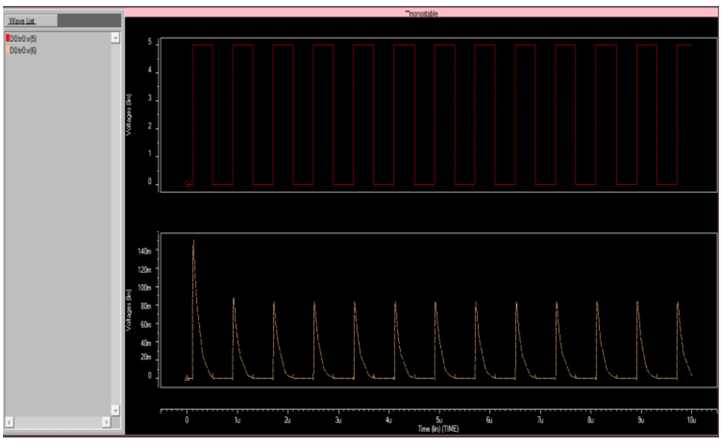

Fig.9. Monostable Multivibrator using CMOS logic

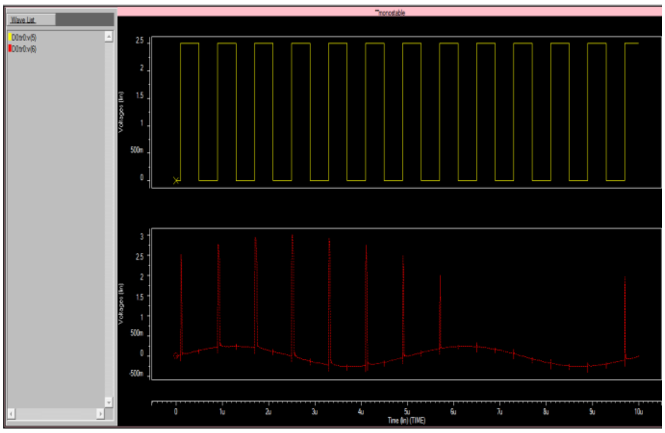

Fig.10. Monostable Multivibrator using Subthreshold Adiabatic logic

C. Bistable Multivibrator

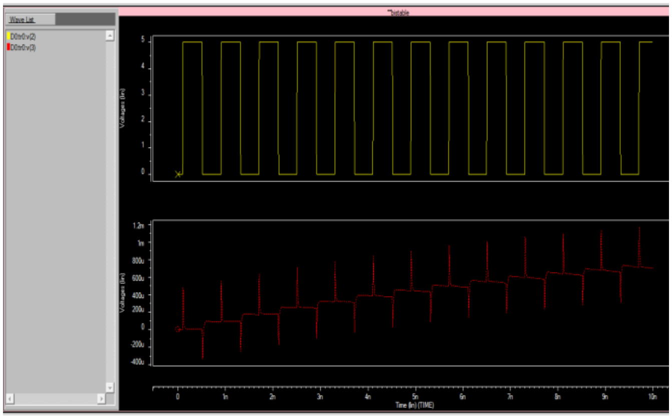

Fig.11. Bistable Multivibrator using CMOS logic

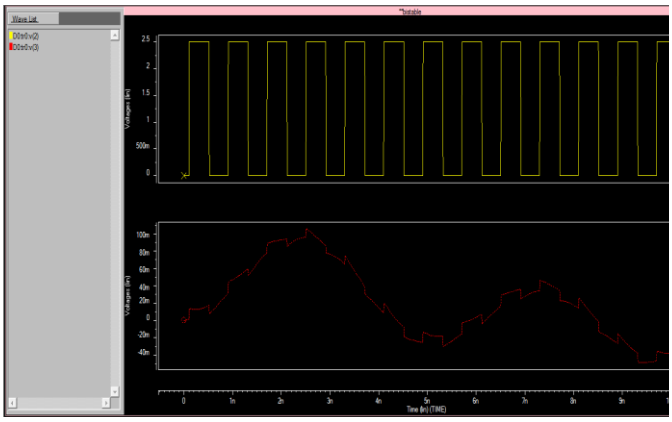

Fig.12. Bistable Multivibrator using Subthreshold Adiabatic logic

TABLE I. COMPARING POWER DISSIPATION

Type of Multivibrator	Power Dissipated Using CMOS Logic(Watts)	Power dissipated using subthreshold adiabatic logic(Watts)
Astable	2.2330E-03	7.3092E-04
Monostable	1.5047E-03	5.8836E-04
Bistable	1.1851E-03	3.2888E-04

V. CONCLUSION

This paper presents an effective implementation of multivibrator circuits using two phase clocking subthreshold Adiabatic Logic. The results of the multivibrators implemented using this logic have been compared with respective CMOS logic and found that by using two phase clocking subthreshold adiabatic logic, power dissipated is less.

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