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COUNTER BASED LOW POWER CMOS TEMPERATURE SENSOR FOR LOW-FREQUENCY APPLICATIONS

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ABSTRACT

We Propose a completely coordinated temperature sensor for battery-worked, ultra-low power exhibited RFID application. Senor task depends on temperature independent /dependent current sources that are utilized with oscillator and counters to produce a Digital temperature code. Dissimilar to Conventional temperature sensors are based on band gap reference and ADC that expend extensive measure of energy. An improved counter approach is utilized here rather than the regularly utilized complex devastation channel strategies. This approach is fitting for applications that have low examining rate of the temperature. The outline accomplishes one degree precision over the range 0°C to 85°C which is appropriate for generally applications. Utilizing such approach save power and area. With a specific end goal to expand the temperature affectability and dynamic range a supply voltage of 1V is utilized, The sensor is actualized in 0.18µm CMOS and keeping in mind that devouring low power. Temperature sensor has a 10 - bit digital output code over a temperature scope of 0ºC to 85ºC.

1. INTRODUCTION

Radio Frequency Identification (RFID) innovation is generally utilized as a part of different applications, for example, real-time production monitoring, security and supply chain management.[1] While the present RFID tags are typically aimed at application that require

identification, Future generation, of RFID tags will have the capacity to detect and give rich data about the environment. Specifically, temperature monitoring RFID tag can be utilized in a variety of application for commercial and industrial applications.[12]

Different kinds of temperature sensors have been designed in CMOS technology. Most conventional temperature sensors depend on bipolar intersection transistors (BJTs). Thus, MOSFET-based temperature sensors targeted for wireless system have been presented. For low power activity, time-to-digital[2,3] or frequency to- digital conversion[4,5] is utilized rather than ADCs. Temperature can be computed utilizing temperature-dependent frequency or pulse. These sensors consume less power than BJT based sensors.

In this paper, a low power high speed Counter -based temperature sensor for low frequency application is displayed. A single phase of an oscillator comprises an inverter took after by transmission gate (TG). To reduce static power consumption, the first stage utilizes a NAND gate to prevent unnecessary oscillation.

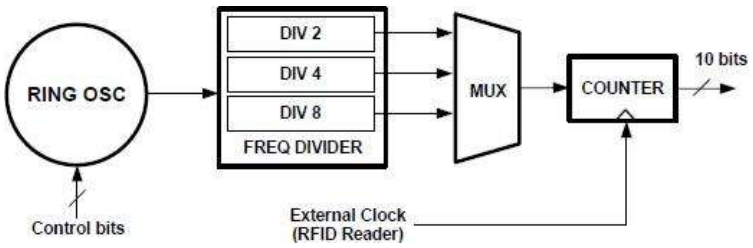

Fig.-1.

2. Voltage Controlled Ring Oscillator

The proposed Temperature sensor made out of ring oscillator, a Frequency divider, a multiplexer, and a 10-bit counter is appeared in figure1. Change of temperature to digital output is accomplished by counting the quantity of clock edges of oscillator during sampling period. Produced frequencies are changed over into an digital output through asynchronous counter.[6]

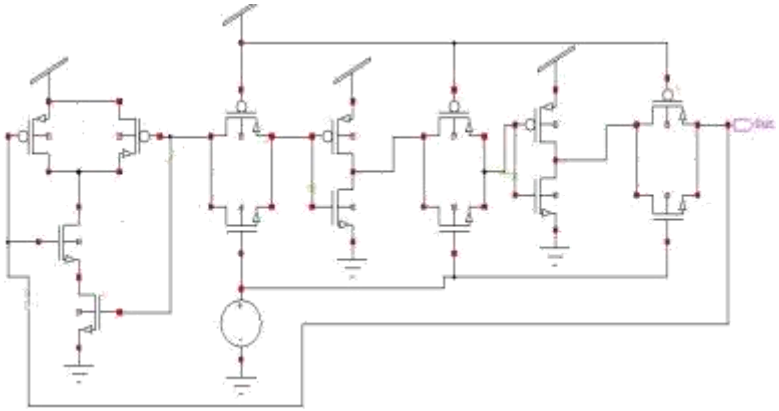

Figure 2: Schematic of ring oscillator with NAND gate.

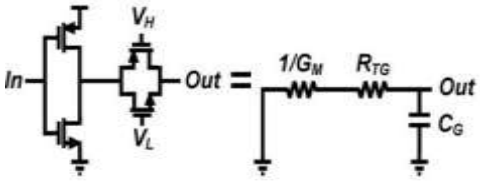

Figure 3: RC small signal model.

Oscillator frequencies are controlled by adjusting the resistance of transmission gate (R_{TG}) with voltages (V_H and V_L) from the previous stage Using RC model the delay of each stage cab be expressed as[7]

$$t_d = \frac{C_G(1+g_M R_{TG})}{g_M} \quad (1)$$

Where g_M is the transconductance of single inverter and C_G is the total gate capacitance of stage (including both NMOS and PMOS). It can be seen that for $g_M R_{TG}$ 1, each stage delay will be determined by R_{TG}, rendering inverter delay temperature dependence negligible.

Effective resistance of R_{TG} is an average value of V_{TG}/ I_{TG} during transition, where V_{TG} and I_{TG} are voltage and current across a transmission gate, respectively. Given a step response of a rising input and $V_{DD}/2$ as a switching point, I_{TG} will be main same during transition as V_{ds} (=$V_{DD}/2$) is kept above $3V_T$. In this case, effective resistance for a falling transition can be approximated as follows[8]

$$R_{TG,effective} = \frac{\ln 2}{V_{DD}/2} \int_{V_{DD}/2}^{V_{DD}} \frac{V}{I_{TG}} dV \approx \frac{V_{DD}}{2I_{TG}} \quad (2)$$

Similar discussion also holds for a rising transition. From (1) and (2), the oscillation frequency F_{osc} of an N-stage oscillator can be expressed as:

$$f_{osc} = \frac{1}{2Nt_d} = \frac{g_M}{2NC_G(1+g_M R_{TG})} \approx \frac{I_{TG}}{NC_G V_{DD}}, (g_M R_{TG} \geq 1 \quad (3)$$

Therefore, the time delay of an individual inverter decreases as the temperature increases, consequently as the temperature increases, the frequency of the ring oscillator increases.

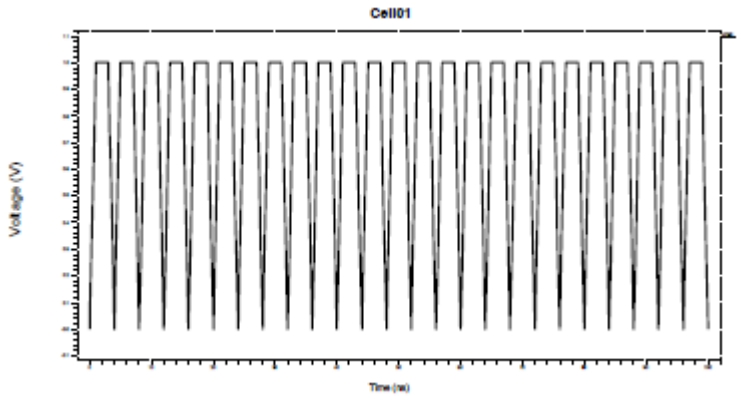

Figure 4: Output waveform of voltage controlled ring oscillator.

The schematic of ring oscillator appeared in fig 2. The oscillator is made out of transmission gate and to reduce static power utilization, the main stage utilizes a NAND gate to prevent the unnecessary oscillation. All components of ring oscillator are intended to work at supply voltage of 1V. Because of the temperature dependence of threshold voltage, the oscillator works in sub-threshold, near sub –threshold or above threshold region as the temperature increments. Consequently, the output frequency of ring oscillator has a wide dynamic range.[11]

Table I: Comparison of Different Voltage Controlled Ring Oscillator in Terms of Supply Voltage, Frequency Power Consumption.

[13] Design 1	**Supply voltage**	0.7V	0.8V	0.9V	1.0V
	frequency	338.98khz	833.33khz	900.33khz	927.23khz
	Power dissipation	23.83 µW	53.12 µW	87.71 µW	130.67 µW
[15] Design 2	**Supply voltage**	0.7	0.8	0.9	1.0
	frequency	500khz	600khz	800khz	1000khz
	Power dissipation	66.27µW	48.13 µW	22.16 µW	0.163mW
[14] Design 3	**Supply voltage**	0.7	0.8	0.9	1.0
	frequency	4Hz	174Mhz	216Mhz	256Mhz
	Power dissipation	18.63 µW	52.99 µW	56.83 µW	61.61 µW

The input voltage is fluctuated from 0.7 to 1V, in step of 0.1V and the time period at different value of voltages from the waveform (Fig.4) can be acquired. After that Frequency is computed by taking inverse of the time period. Table I indicates control utilization and frequencies for various estimations of voltages.

3. Frequency Divider and Mux

Another useful feature of the D-type Flip-Flop is as a binary divider, for **Frequency Division** or as a "divide-by-2" counter. Here the inverted output terminal Q (NOT-Q) is connected directly back to the Data input terminal D giving the device "feedback" as shown in Figure 5.

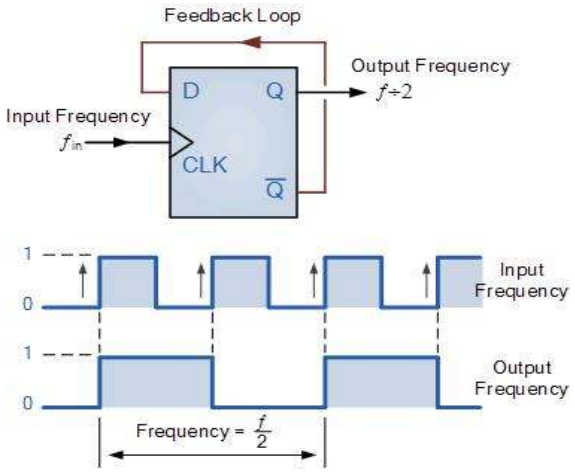

Figure 5: Block diagram of divided by 2.

Using master slave D flip – flop we implemented the divide by 2, 4 and 8 prescaler. And mux is also implemented by using transmission gate. Throughout these techniques can reduce the power of the circuit and improve the overall performance of the circuit.[9,10]

4. Conventional Counter

A counter circuit is normally developed of various flip-flops associated. Counters are a broadly utilized segment in computerized circuits, and are produced as particular coordinated circuits and furthermore joined as parts of larger integrated circuits.

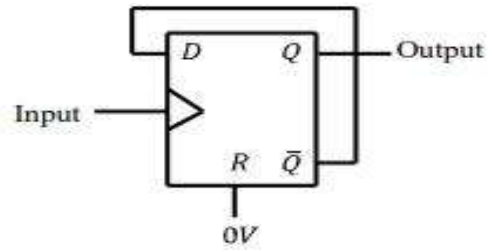

Figure 6: 1- bit counter block diagram.

5. Conventional CMOS Implementation of D – flip flop 1-bit counter

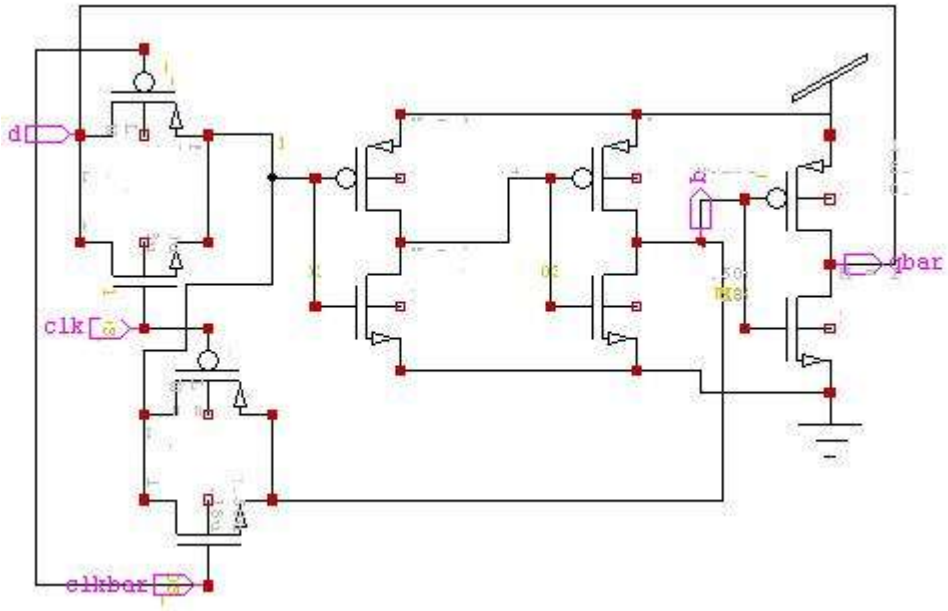

Figure 7: Schematic conventional CMOS D flip flop 1- bit counter.

6. Proposed Counter

In this paper we proposed a 1- bit counter using different D- flip flop like ETSP based, TSPC based and IETSP based D flip flops , Among all these design we get the TSPC D –flip flop based counter gives the better result.

An improved counter approach is utilized here rather than the regularly utilized complex devastation channel strategies. This approach is fitting for applications that have low examining rate of the temperature. The outline accomplishes one degree precision over the range 0°C to 85°C which is appropriate for generally applications. Utilizing such approach save power and area.

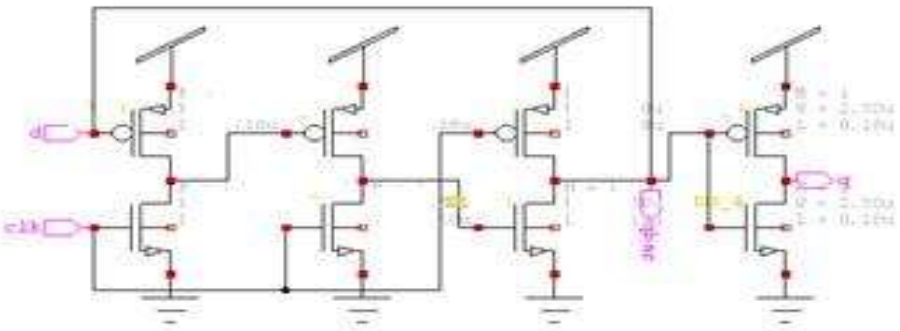

Figure 8: Proposed Schematic of 1- bit counter using TSPC D -flip flop.

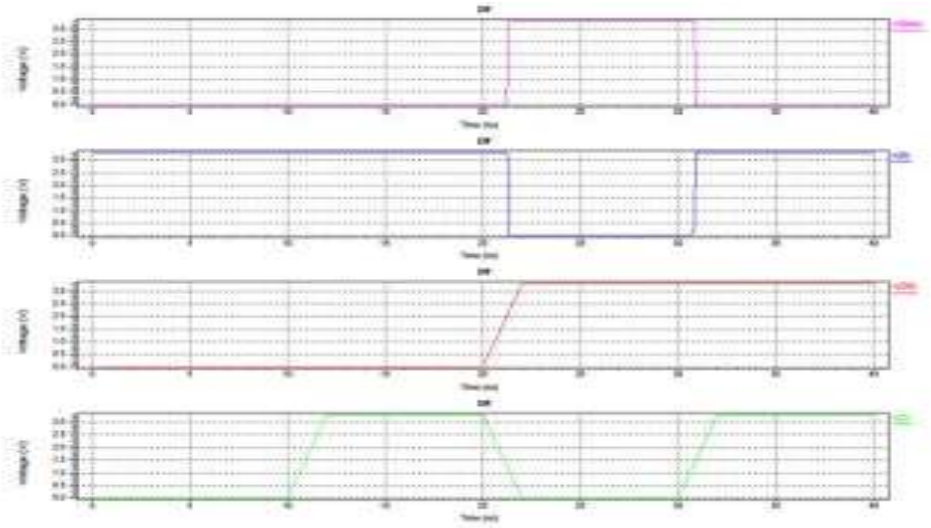

Figure 9: waveform of TSPC D- flip flop 1- bit counter.

Table II: Comparison table of conventional and proposed d flip flop 1- bit counter of power dissipation & delay at different voltage.

Design parameter	Conventional CMOS D-flip flop	ETSPC D- flip flop	Master-slave D - flip flop	Improved ETSPC D-flip flop	Proposed TSPC D flip – flop
Process(um)	180	180	180	180	180
Supply voltage	1.0	0.9V	1.0V	0.7V	1.0V
Power Consumption	0.12mW	0.15Mw	0.87mW	37.25µW	7.9µW
Delay(ns)	90.45	90.43	90.01	89.78	84.45
Transistor count	10	8	10	9	11

The input voltage is varied from 0.7 to 1V, in steps of 0.1V and then time period at different values of voltages from the waveform (Fig.9) can be obtained. After that frequency is calculated by taking inverse of the time period. Table II shows the 1- bit counter using different D flip flops power consumption and time delay for different values of voltages.

In this paper, mainly we work on counter using different D flip flop. We found that the conventional CMOS D- flip flop using 1 - bit counter consume more power as compare to TSPC D- flip flop.

We obtain a digital output code a 10- bit digital counter based temperature sensor, which use the TSPC D- flip flop follow in shown fig. 7. Since it is very difficult to predict an accurate free running frequency of the oscillator at the simulation level, a frequency divider with

division values of 2, 4 and 8 is followed by the digital counter for robust operation and ensures functionality.[12]

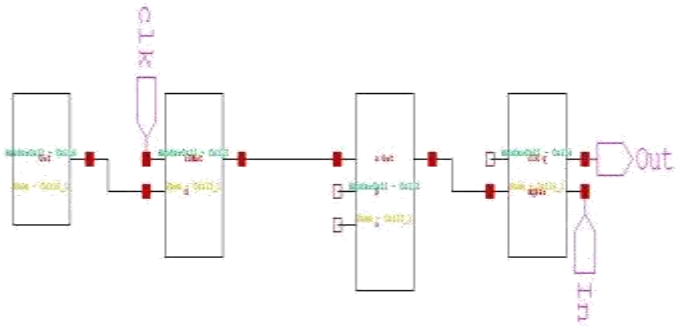

Figure 10: Schematic of proposed temperature sensor.

Fig.10 is the schematic view of proposed temperature sensor and Fig.11 shows the Temperature variation with respect to Oscillation Frequency.

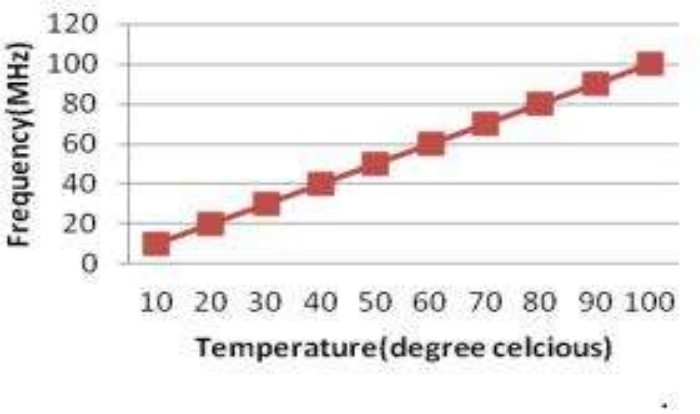

Figure 11: Temperature Characteristic of Ring Oscillator showing Frequency of Oscillation Linear to Temperature.

7. CONCLUSION

A Low power counter based -CMOS temperature sensor has been displayed. This paper's aim is to reduce the power of counter and improve the overall performance of temperature sensor. For low power task, the ring oscillator is intended to be powered at voltage of 0.7-1V. With a specific end goal to deal with process variety, the frequency of the oscillator can be carefully trimmed. At last, since the temperature sensor exploits the temperature dependence of the edge voltage. Ring oscillators are essential building block of complex intergraded circuits. They are for the most part utilized as clock producing circuits. The proposed temperature

sensor has full range voltage controllability along with a wide tuning range and is most reasonable for low-voltage and low power consumption.

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