Comparative Analysis on Voltage Reference Circuits

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Abstract : In the modern world the low power supply voltage circuits are major attractable to the most extent because of the long battery runtime for the portable devices like the mobiles, laptops etc. the reduction of the power supply voltage has became the one of the most challenging issue in the VLSI technology industries. So voltage reference circuits are used to reduce the supply voltage because they can operate in the low supply voltage. The voltage reference circuits play an important role in the analog systems. The voltage reference circuit is a simple device having the one simple functionality that is it generates the exact output voltage without depending on the factors like input supply voltage, load current and the temperature change. The voltage reference provides the recommended output voltage which is needed by the circuit for its required measurements. In this paper the different types of voltage reference circuits are discussed and the literature review of the technologies used in different voltage reference circuits have been performed and comparison of different technologies have been performed.

IndexTerms **- Modes of operation, Types of voltage reference circuits, Specifications.**

I. INTRODUCTION

The voltage reference circuits play an important role in the analog systems. The voltage reference circuit is a simple device having the one simple functionality that is it generates the exact output voltage without depending on the factors like input supply voltage, load current and the temperature change [1]. The voltage reference provides the recommended output voltage which is needed by the circuit for its required measurements. The voltage reference and the voltage regulators having the same functionality providing the exact output voltage but the voltage reference circuits have come over with some advantages from the voltage regulators such as the voltage regulators provides the higher output noise and it cannot provide the stable output voltage for a longer period of time [2]. The main applications of the voltage reference circuits are used in the Analog to digital converters, servo systems, smart sensors and the portable devices battery systems for the long runtime of the battery.

II. MODES OF OPERATION

The reference circuits can operates in any of the modes basically it has two types of the operating modes they are as follows:
1) SERIES MODE.
2) SHUNT MODE.

i) Series Mode: The series mode voltage reference provides the low noise. The series mode reference circuits is higher accurate than the shunt mode voltage reference. The input supply voltage of the series mode voltage reference is limited to the device operation and cannot function for the high input supply voltage [3]. This series mode voltage reference provides the positive output voltage**.**

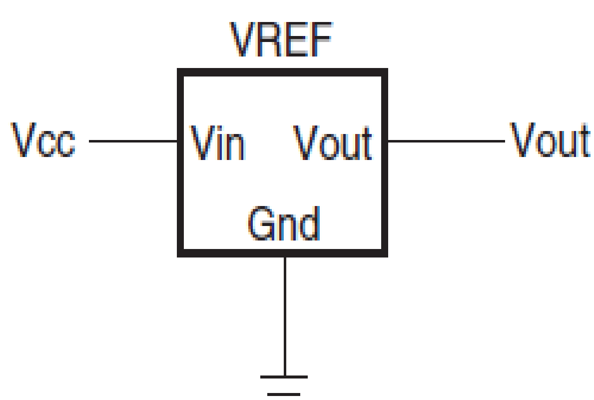

Fig1: Series mode reference circuit.

ii) Shunt Mode: The shunt mode reference circuit can be operated by the low current and this shunt mode reference circuit can operate at very high input supply voltage because of the resistor present in the circuit it can handle the high voltages. This shunt mode reference circuit is less accurate than compared with the series mode reference circuit[4]. This shunt mode reference circuit provides the negative reference voltage.

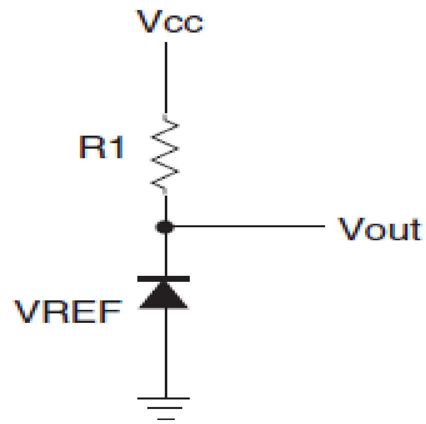

Fig2: Shunt mode reference.

III. **DIFFERENT TYPES OF VOLATGE REFERENCE CIRCUITS**

There are three types of the voltage reference circuits they are as follows:
1) Band gap reference circuit.
2) Buried zener reference circuit.
3) XFET reference circuit.

1) Band gap reference circuit: This Band gap reference circuit is used mainly because this reference circuit requires the low supply voltage of less than the 5 V and operates at the low current which is less than the 1mA. The block diagram of the Band gap reference circuit shown in the figure 3

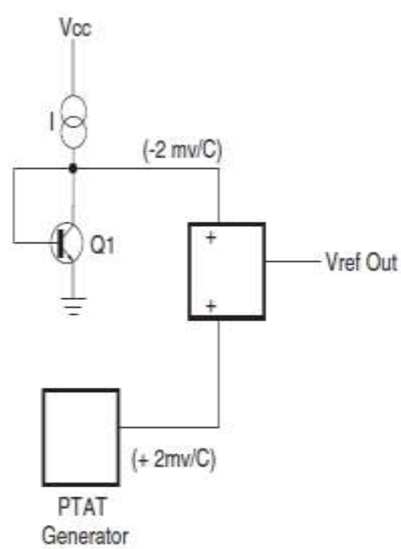

Fig3: Band gap reference circuit

In this Band gap reference circuit it has two voltage source generator the first one is the forward bias transistor Vbe and the second source generator is the proportional to absolute temperature generator (PTAT) which generates the other voltage and both the voltages are given to the summing circuit and it gives the output reference voltage Vref without any temperature drift the both temperature drift will be cancelled by each other in the summing circuit [5].This Band gap reference circuit is mostly used in the analog circuit because of its main application of operating in the low supply voltage which is useful in the portable devices and the one more advantage is that it avoids noise. The drawback of this reference circuit is that it requires a standard input supply voltage such as 5V, 4.5V, 2V etc.

2) Buried zener reference circuit: This Buried zener reference circuit is mainly used for the manufacturing of the good quality reference circuit with very less noise. The circuit diagram of the Buried zener reference circuit is shown in the fig4.

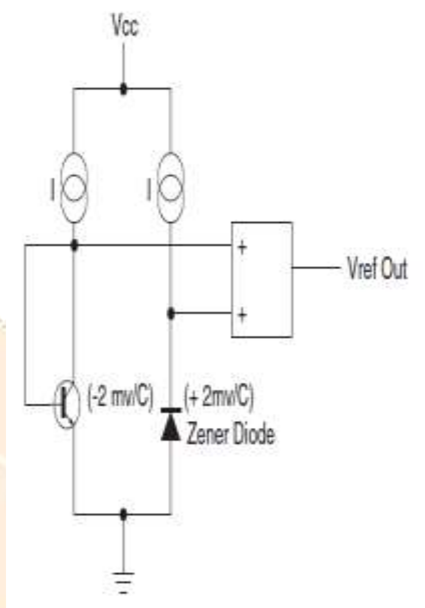

Fig4: Buried zener diode reference circuit

Basically the zener diode initially have the high noise due to the manufacturing defects like crystal imperfection but this prove have been resolved by the Buried zener diode by moving the zener junction below the surface from the surface of the die this reduces the manufacturing defects and reduces noise. The drawback of this Buried zener reference circuit is that it cannot operate in the low input supply voltage because the zener diode cannot work under the supply voltage of 0.7V [1]. So the minimum supply voltage required to operate this circuit is 0.7V and the main advantage of this Buried zener reference circuit is it gives lees noise and it used to manufacture the standard voltage reference circuits.

3)XFET reference circuit: This XFET reference circuit functions as same as the Band gap reference circuit the only difference or change of the XFET reference circuit is that it uses the junction field effect transistors (JFET) instead of the bipolar junction transistors (BJT) used in many of the Band gap reference circuit. The circuit diagram of the XFET reference circuit is as shown in the figure5.

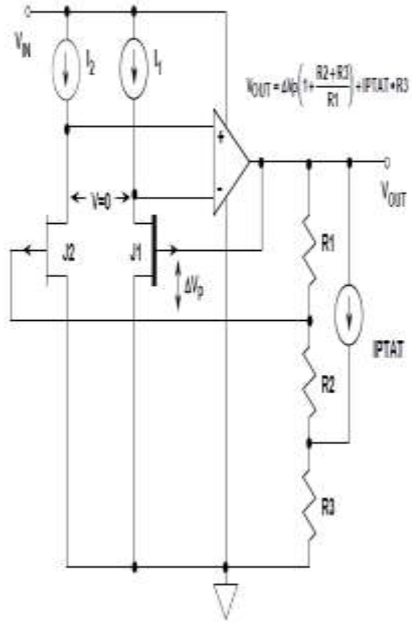

Fig5: XFET reference circuit

From the above figure J1, J2 are the two field effect transistors. The XFET reference circuit also operates the low supply voltage which is less than the 5V same as the Bandgap reference circuit but this XFET reference circuit over comes draw back like use of the standard input power supply voltage values like 5V, 4.5V etc and also the less noise compared to the bandgap reference circuit.

IV. REVIEW OF LITERATURE

Byung-Do Yang [1]: In this paper they have designed a subthreshold CMOS voltage reference circuits that reduces minimum supply voltage. The conventional voltage reference circuit consists of a amplifier and in the proposed design the amplifier is replaced by the low voltage comparator, a charge pump and a digital control unit which produces a 0.5MHZ signals by taking the clock frequency as the 1MHZ. The proposed voltage reference circuit is implemented on the 110nm technology and consumes 5.35uW at the input supply voltage as 250mV and the frequency of 1MHZ. This proposed design of the sub threshold CMOS voltage reference circuit can operate at the minimum supply voltage of 242mV.

PieroMalcovati,et.al [2]: In this paper they have designed a bandgap circuit which can generate a reference voltage of 0.54V and can operate with a 1V supply voltage which consumes a 92uW. The proposed design of band gap circuit uses a operational amplifier which can be able to achieve the virtual zero systematic offset and operates at the 1V supply voltage. The proposed band gap circuit allows the straight forward implementation of the curvature compensation method without any additional operational amplifiers and the complex circuits by using the same transistors in the circuit by reducing the chip area while fabricating.

P.Kinget,et.al[3]: The conventional voltage reference circuits so far designed has been designed can operate at the supply voltage of the 0.7V and could not operate at the supply voltage less than the 0.7V because of the forward bias operation of the P-N junction diode. In this paper they have introduced two main techniques to operate the reference voltage below the 0.7V. The two ultra low power design techniques used in this paper are:

1) Reference circuits based on the CMOS compatible schottky diode.
2) MOS reference circuits.

By using these two techniques they are able to operate the voltage reference circuits with the supply voltage less than the 0.7V i.e nearly to the 0.45V.

Luca Magnelli,et.al [4]:. In this paper they have designed a subthreshold CMOS voltage reference circuit. In this design all the transistors are operating in the weak inversion region. The proposed design produces a mean reference voltage of 257.5mV this design has been implemented on the 180nm technology and this subthreshold CMOS voltage reference circuit can also operate in the low supply voltage of 0.45V and the area in the chip is 0.043mm2 and operates in the temperature range between the 0 to 125 degree centigrade.

YutaoWang,et.al [5]:. In this paper they have designed a low voltage low power CMOS subthreshold voltage reference circuit without using the resistors and the bipolar junction transistors. In this design for improving the temperature stability they uses the second order compensation. The supply voltage and the power dissipation are reduced by making all the MOS transistors operating in the subthreshold region and bulk drain technique .the proposed design has implemented on the 180nm technology. This design can operate at the supply voltage of 0.45V and the power consumption of 14.6nW and temp ranges between the -40 to 125 degree centigrade and area on the chip is 0.012mm2.

Table1: Comparison of references

	[1]	**[2**]	**[3**]	**[4**]	**[5**]	**[6**]	**[7**]
Process[nm]	110	NA	130	500	90	180	180
Type	CMOS	Bandgap	Bandgap	CMOS	CMOS	CMOS	CMOS
Area[mm^2]	0.013	NA	0.07	NA	0.07	0.043	0.012
Power[uW]	5.35	92	0.17	NA	482	0.0026	0.146
Vddmin[mV]	242	1000	750	1000	550	450	450
Vref[mV]	195.6	540	256	357	241	263.5	118.46
Tempcoef[ppm/c]	134	7.5[ppm/k]	40	9.9	150	142	63.6
Temprange(degree centigrade)	NA	NA	-20-85	10-100	20-150	0-125	40 - 125

V. CONCLUSION

Analysis of the MAC unit with the Wallace tree multiplier , Baugh wooley multiplier and pipelining technique has done by using cadence virtuoso 180nm technology. The Baugh wooley algorithm is a relative straightforward way of doing signed multiplications. The Baugh wooley multiplier reduces the partial products in the MAC unit. So the power consumption is low. From the above results it shows that by using Baugh wooley multiplier the speed of the circuit has been increased and due to pipelining technique the power consumption also very less as compared to the Wallace tree multiplier. In future if it is possible reduce the power consumption of the Baugh wooley multiplier so that the MAC unit speed will increase.

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