INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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DESIGN OF AREA-EFFICIENT BANDGAP REFERENCE IN 0.18µm CMOS TECHNOLOGY

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Accepted Date: 27/02/2016; Published Date: 01/03/2016

Abstract: - A novel technique for a low supply voltage temperature-independent and area-efficient CMOS bandgap reference (BGR) is proposed in this paper. The low supply reference circuits is replaced by conventional bandgap reference circuit with the scaling of supply voltages, the threshold voltages don't scale proportionally. The proposed circuit uses only three bipolar transistors to generate a reference voltage so that significant area reduction can be achieved. For design bipolar transistor device mismatch can be eliminated. The circuit produces an output voltage of about 650 mV, and simulated results show that the BGR is totally independent from temperature variation. The average current consumption is about 50 µA. The circuit was designed and simulated in 0.18µm CMOS technology in Tanner 13 tool.

Keywords: Bandgap Reference (BGR), Area efficient, Low supply.

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How to Cite This Article:

Vrushali G. Nasre, IJPRET, 2016; Volume 4 (7): 64-71

PAPER-QR CODE

1. INTRODUCTION

Precise reference voltage sources are an essential part of many electronic systems. An important part in the design of analog integrated circuits is to create reference voltages and currents with well-defined values. To accomplish this on-chip, the bandgap reference circuits are commonly used. These circuits allow the design of supply voltage and temperature independent reference voltages [1-2]. A major application for this reference voltage is in A to D converter, where the input voltage is compared to several reference levels in order to determine the corresponding digital value. On the other hand, the demand for low area, low voltage and low power operation becomes especially apparent. The high precision bandgap reference circuit with low supply voltage is expected for battery operated portable products. In CMOS technology, the conventional bandgap reference circuit usually uses the diodes to get the high precision bandgap voltage.

In bandgap reference, an output voltage with low sensitivity is obtained as the sum of a voltage that is proportional to absolute temperature (PTAT) and a voltage with negative temperature coefficient, which is complementary to absolute temperature denoted as (CTAT).

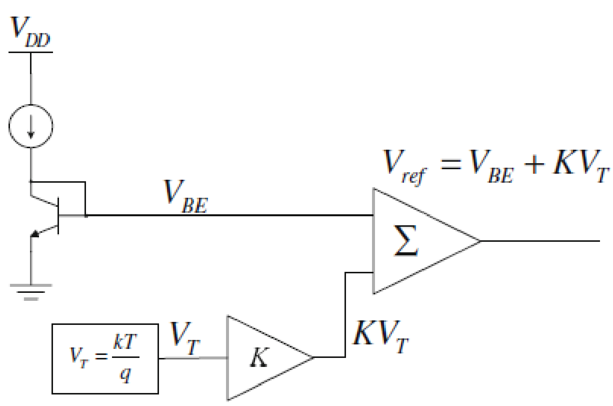

Figure 1. Block diagram of a bandgap voltage reference [1]

The PTAT voltage is generated by taking the difference in the base-emitter voltages of two bipolar transistors. The CTAT voltage is usually obtained from the voltage across a forward biased p–n junction or the base-emitter voltage (VBE) of a diode connected bipolar junction transistor (BJT) as illustrated in Figure1. The concepts of BGR are shown in Figure2.

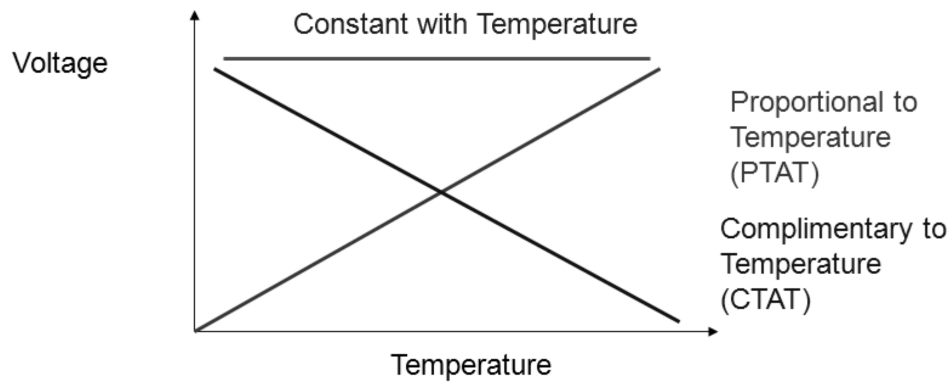

Figure 2. Concept of BGR

The term V_T indicated in this figure1 is the thermal voltage described by (1), where K is the Boltzmann Constant, q is the electron charge and T is the temperature [3].

$$V_T = \frac{kT}{q} \qquad (1)$$

2. PRINCIPAL OF OPERATION

In Bandgap reference circuit reference voltages or currents that exhibit little dependence on temperature prove essential in many analog circuits. It is interesting to note that, if a reference is temperature-independent then it is usually process-independent as well because most process parameters vary with temperature. In order to generate a quantity that remains constant with temperature, we assume that if two quantities having opposite temperature coefficients (TCs) that are CTAT and PTAT added with proper weighting, the result displays a zero temperature coefficients. The forward voltage of a pn-junction diode and the base-emitter voltage of bipolar transistors exhibits a negative temperature coefficients i.e. CTAT. If two BJT bipolar junction transistors operate at unequal current densities, then the variation between their base-emitter voltages is directly proportional to the absolute temperature. As shown in Figure 3, if two identical transistors (I_1 and I_2) are biased at collector currents of nI_0 and I_0 and their base currents are very small and can be neglected, then

$$\Delta V_{BE} = V_{BE1} - V_{BE2}$$

$$\Delta V_{BE} = V_T \ln\left(\frac{nI_0}{I_1}\right) - V_T \ln\left(\frac{nI_0}{I_2}\right)$$

$$\Delta V_{BE} = V_T \ln n$$

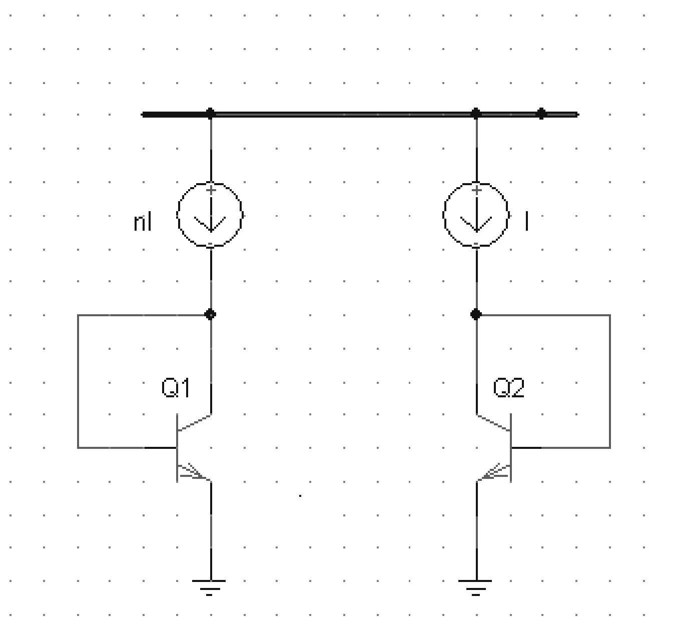

Figure 3: Generation of PTAT voltage

Thus, V_{BE} the difference shows a positive temperature coefficient and given by

$$\frac{\partial \Delta V_{BE}}{\partial T} = \frac{k}{q} \ln n$$

The proposed bandgap reference circuit is as shown in Figure 4 where M_1 & M_2 and M_3 & M_4 are identical which having $I_{D1}=I_{D2}$ so that voltage at X and Y are equal i.e. $Vx=Vy$.

3. SIMULATION RESULT

Simulation result of variation of VBE with temperature as shown in Figure 5. Where temperature is varies from -40^0C to 60^0C. The Figure 6. Shows the variation of ΔV_{BE} with respect to temperature the maximum change in ΔV_{BE} is not more than 1.05mV. The Variation of node X and Node Y potential with Temperature is as shown in Figure 7. The simulation result shows that there is identical variation in node potential with respect to temperature.

The output voltage is independent with respect to change in temperature. The simulation result of Variation of Output Reference voltage with Temperature is as shown in Figure 8.

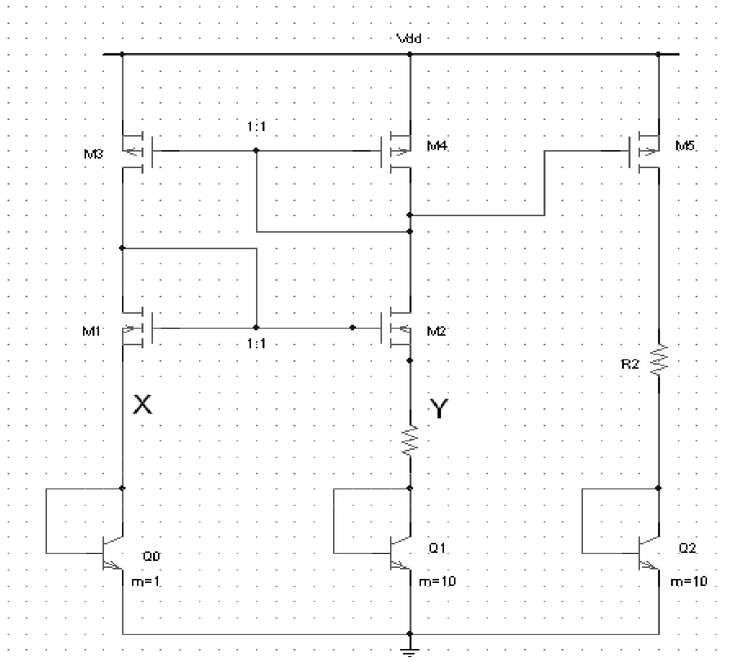

Figure 4. Proposed Bandgap Reference Voltage Circuit

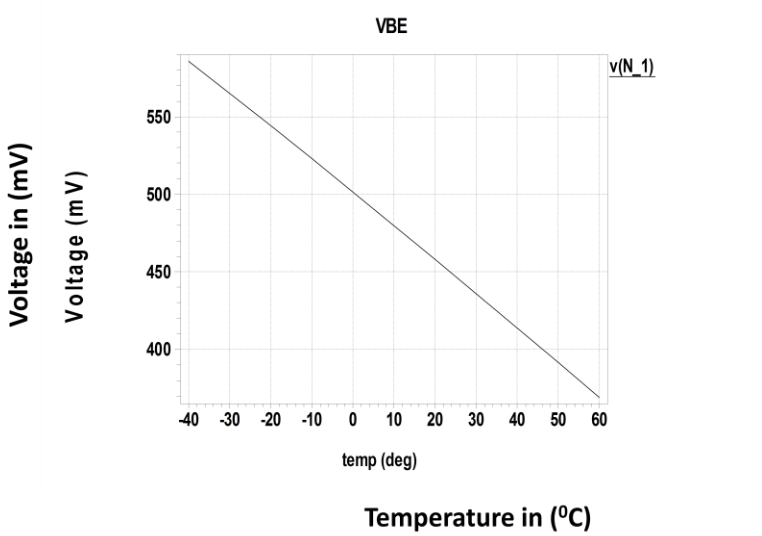

Figure 5. Variation of VBE with Temperature

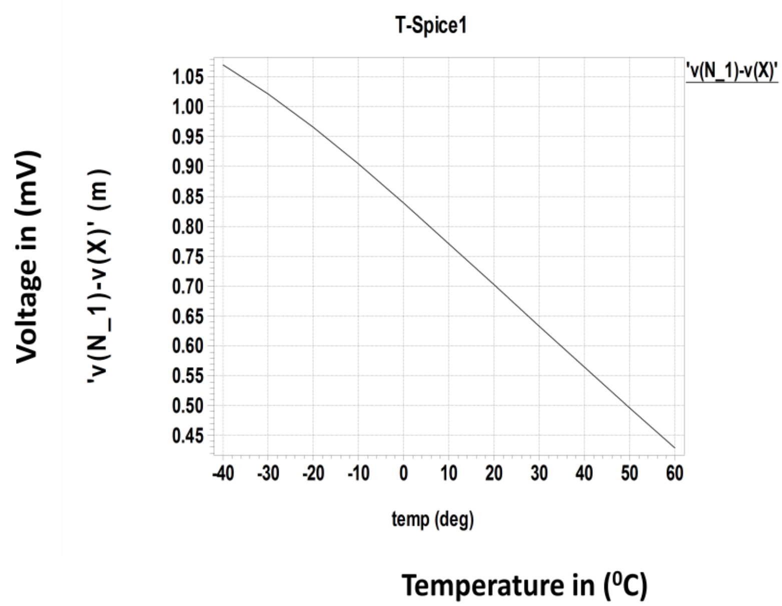

Figure 6. Variation of ΔVBE with Temperature

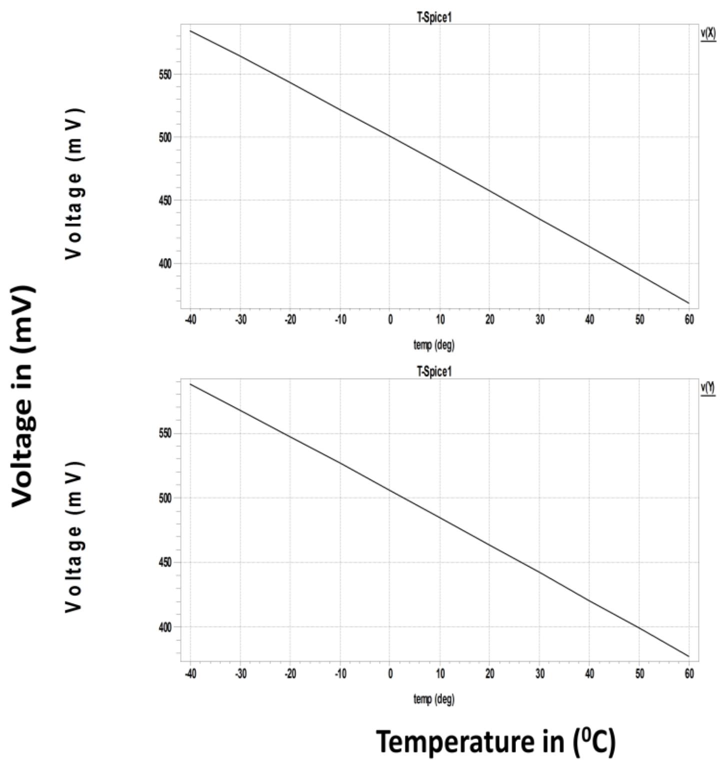

Figure 7. Variation of node X and Node Y potential with Temperature

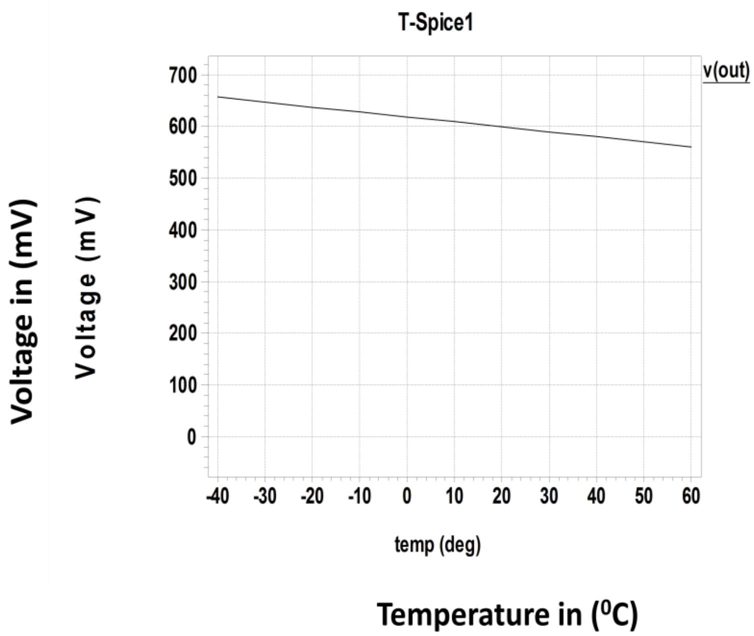

Figure 8. Variation of Output Reference voltage with Temperature

4. CONCLUSION

A low-voltage, low power three bipolar transistor bandgap reference circuit in the standard 0.18μm CMOS process is presented in this paper. The proposed bandgap reference circuit all MOS transistor are identical so that voltage at X and Y are equal. As a result, the low supply voltage 0.65V bandgap reference circuit with three bipolar transistors appears in this paper. The experimental results have proved that the bangap reference circuit is more stable with temperature variation. The average current consumption is about 50μA. The circuits are simulated in Tanner 13 tool with power supply of 1.8V.

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