

Design a Low Voltage Band Gap Reference by Utilizing CMOS 0.18 μm

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Abstract: The present study examined a Bandgap voltage references (BGRs) with CMOS 0.18 μm technology by using Cadence software. Bandgap voltage references (BGRs) are essential blocks in most analog systems. BGRs are independent of process, independent of supply voltage and independent of temperature. Dependent temperature is the important challenge in BGRs. There are different approaches for design BGRs. One efficient method is using opamp in configuration of BGRs. In this work we utilized an opamp in configuration of BGR by using CMOS 0.18 μm with low supply voltage 1.1v. The results indicated temperature coefficient 540 PPM in range 0 to 100 C°.

Keywords: Bandgap Reference; CMOS 0.18; Opamp; Cadence software

I. Introduction

The Bandgap voltage references (BGRs) are essential blocks in most analog and mixed-signal circuits, for instance, analog-digital and digital-analog converters, voltage regulators, as well as measurement circuits. The main goal of BGRs design is to achieve a low temperature coefficient (TC) over a large temperature range.[1] - [5].

Circuits for generating accurate and stable voltages reference which are independent of temperature are required for a variety of applications. In these circuits, one important technique for temperature independence of the reference voltage is obtained by summing two different temperature dependent voltage sources. A voltage source whose output decreases with increase in absolute temperature is normally utilizing a forward biased diode. The voltage source whose output increases proportional to absolute temperature (PTAT) may be obtained utilizing resistor. An operational amplifier is usually used to sum up these voltages to produce an output that is insensitive to changes of temperature [6], [7].

Most voltage references are usually designed based on a bandgap reference, which usually provides an output voltage of approximately 1.25V. Therefore, the supply voltage for the reference needs to be greater than 1.25V. With the advance in CMOS processes, bandgap references with low supply voltages, such as < 1V, are required. To reduce the supply voltage, different voltage reference techniques have been developed [1] – [5]. Some of these techniques used devices that are compatible with CMOS processes, for instance, Schottky diodes [2], dynamic threshold transistors (DTMOSTs) [3], gate-voltage difference of a MOSFET [4], etc.

II. Result And Discussion

One conventional circuit in literature has been illustrated in Fig1.

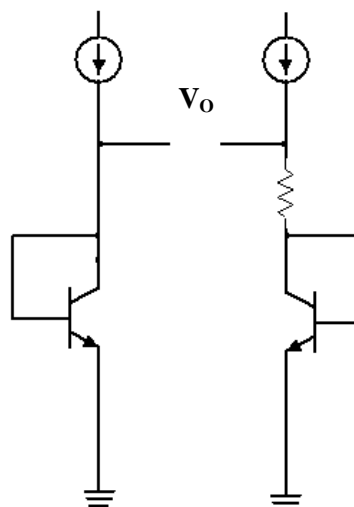


Fig.1. Conventional circuit for Voltage Reference

In this circuit:

$$V_{BE1} - V_{BE2} = RI \quad (2)$$

$$RI = V_T \ln n \quad (3)$$

$$V_{O2} = V_O = V_{BE2} + V_T \ln n \quad (4)$$

$$\frac{\partial V_O}{\partial T} = \frac{\partial V_{BE2}}{\partial T} + \frac{K}{q} \ln n = 0 \quad (5)$$

$$\frac{\partial V_{BE2}}{\partial T} + \frac{K}{q} \ln n = 0 \quad (6)$$

$$\frac{\partial V_{BE2}}{\partial T} = -\frac{K}{q} \ln n \quad (7)$$

$$\ln n = \frac{q}{K} \left(-\frac{\partial V_{BE2}}{\partial T} \right) = \frac{T}{V_T} \left(-\frac{\partial V_{BE2}}{\partial T} \right) = \frac{300k}{25mV} \left(1.5 \frac{mV}{k} \right) = 18 \quad (8)$$

According equation mentioned above, $\ln n = 18 \leftrightarrow n = e^{18}$. But, $n=18$ is great amount for area of base-emitter. Therefore, the circuit of figure2 have been presented in literatures in order to solve the problem.

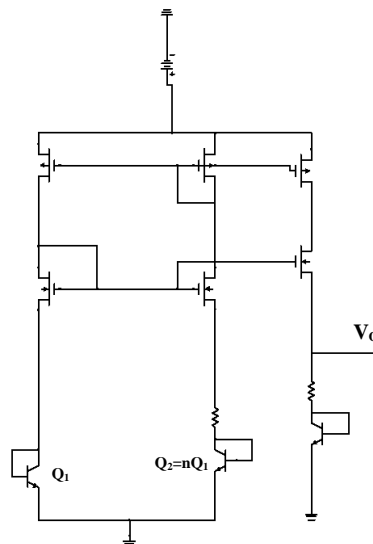


Fig.2. Circuit suggested in literatures for improving performance of voltage reference in conventional circuits (in Fig.1.)

In addition, in this circuit:

$$V_{BE1} = R_1 I_2 + V_{BE2} \quad (9)$$

$$R_1 I_2 = V_T \ln n \quad (10)$$

$$I_2 = \frac{V_T \ln(n)}{R_1} \quad (11)$$

$$V_O = V_{BE2} + \frac{R_2 V_T \ln n}{R_1} \quad (12)$$

$$\frac{\partial V_O}{\partial T} = \frac{\partial V_{BE2}}{\partial T} + \frac{V_T R_2 \ln n}{T R_1} = 0 \quad (13)$$

$$\frac{R_2 \ln n}{R_1} = \frac{T}{V_T} \left(-\frac{\partial V_{BE2}}{\partial T} \right) = \frac{300k}{25mV} \left(1.5 \frac{mV}{k} \right) = 18 \quad (14)$$

We can see, this suggestion is suitable .Because, $\frac{R_2 \ln n}{R_1} = 18$ has been achieved simply.

$$V_O = V_{BE2} + \frac{R_2 V_T \ln n}{R_1} \quad (15)$$

$$\frac{\partial V_O}{\partial T} = 0 \quad (16)$$

$$-\frac{\partial V_{BE2}}{\partial T} = \frac{V_T R_2 \ln n}{R_1 T} \quad (17)$$

$$V_O = -300 \left(1.5 \frac{\text{mV}}{\text{K}} \right) + (V_{BE2} = 700\text{mV}) = 1150\text{mV} \quad (18)$$

III. Simulation

Of course, has been presented circuits by utilizing opamp in literature. In this work, we designed BGR by utilizing opamp. In first step, we illustrated opamp that utilized for this BGR (in Fig.3) and we illustrated its frequency response in figure 4.

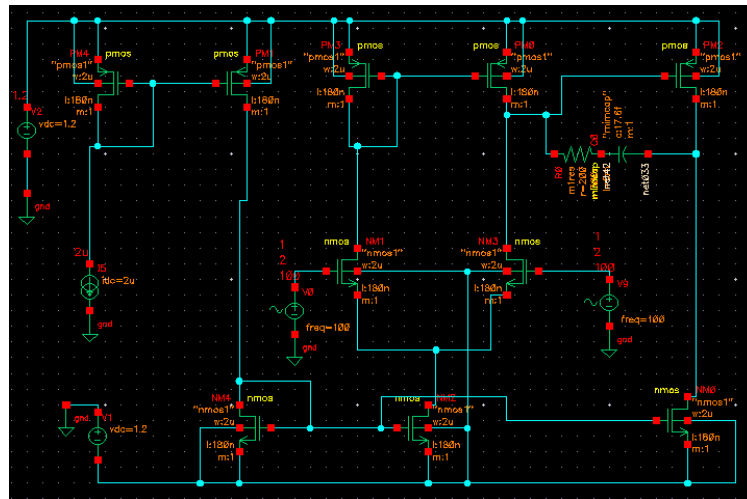


Fig.3. Configuration of Opamp

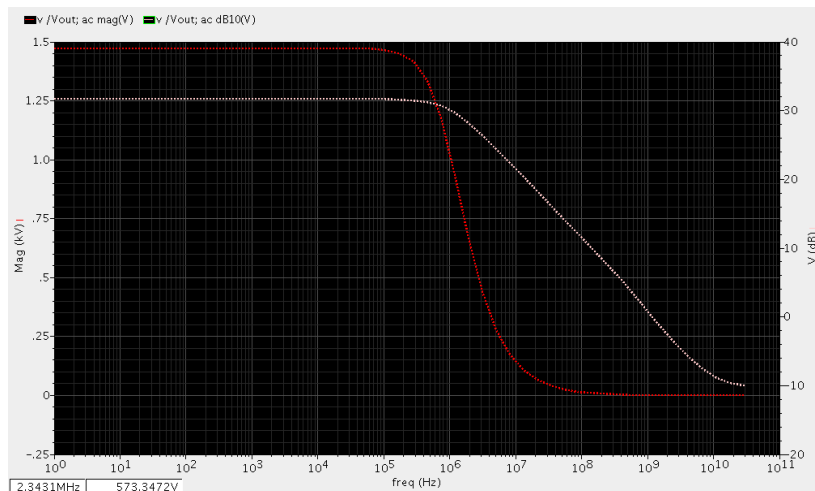


Fig.4. Frequency Response of Opamp

Utilizing opamp in configuration of BGRs causes increase the consumption power. In contrast, it can decreasing temperature coefficient in BGRs. According figure 5 and 6 , utilizing the apamp of figure3 causes decrease temperature coefficient. The temperature coefficient of BGR has been illustrated in figure 6 that is 540 PPM in range 0 to 100 C°.

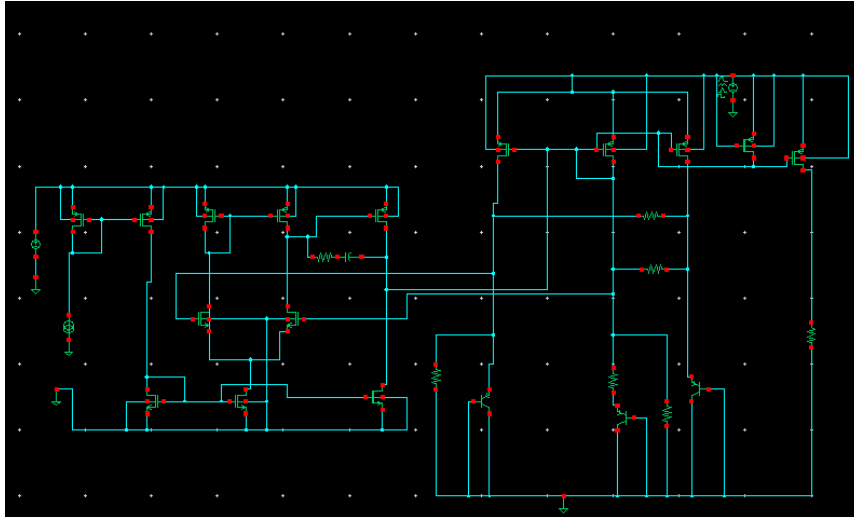


Fig.5. Final Configuration of Band Gap Reference.

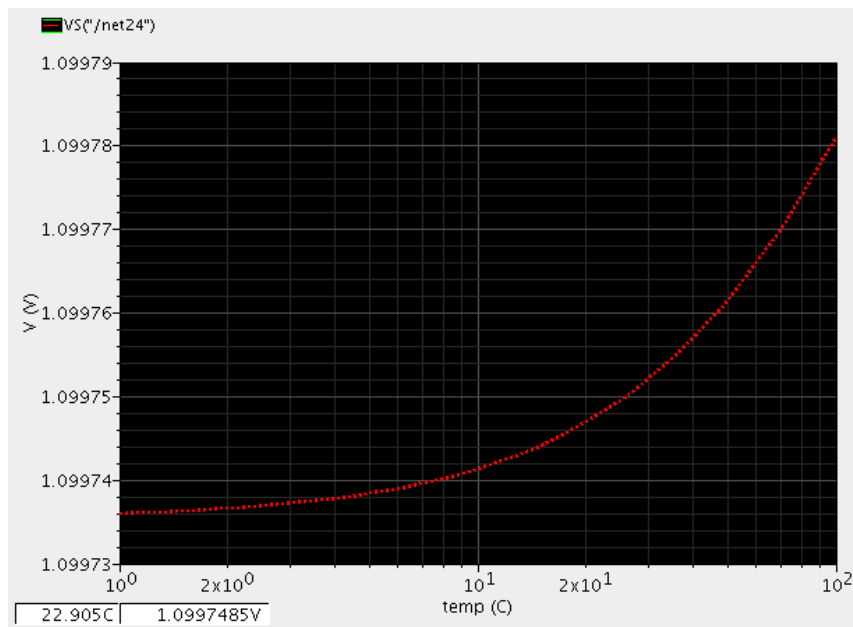


Fig.6. Temperature coefficient of BGR

IV. Conclusion

One important block in most analog and mixed-signal circuits, such as analog-digital and digital-analog converters, voltage regulators are BGRs. In this work, we have designed a low voltage bandgap reference by utilizing opamp and by a conventional 0.18 μm CMOS process. The opamp that has been used in this work has bandwidth 10^5 Hz. The results indicated that utilizing opamp affects improving temperature independence of BGR. Therefore, it causes that the BGR has temperature coefficient about 540 PPM in range 0 to 100 C $^\circ$ with low supply voltage 1.1v.

References

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