Design of Band-gap Reference Voltage Source with High Performance by 0.35μm CMOS Technology

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Abstract

Benchmark for the lower band gap reference voltage source power interference effect the output of the system, in order to improve the performance of the chip based on 0.35μm CMOS (Complementary Metal Oxide Semiconductor) technology, the band gap reference voltage source was designed using the Cadence, and has carried on the theoretical analysis on, the experimental results show that the indicators of the band-gap reference voltage source are normal, the temperature coefficient is about 15.3ppm/°C, the linear adjustment rate is 75.6ppm/V.

Keywords

Band-gap, Reference voltage source, Load transient response.

1. Introduction

Band gap reference voltage source (BGR)[1-4] is one of the most commonly used in power management chips. It can provide a voltage reference independent of the power supply voltage and ambient temperature[5,6]. It is widely used in analog circuits such as dc-dc and LDO, as well as in modular hybrid circuits such as ADC.

2. Operating Principle of Reference Voltage Source With Band-gap

As shown in Fig. 1 for benchmark band-gap reference voltage source (BGR) principle diagram, among them, the M_{p1} M_{p2} are two completely mirror PMOS, R_1, R_2 and R_3 are poly real resistance, usually around kΩ resistance value, Q_1 and Q_2 are PNP transistor, under normal circumstances, Q_1: Q_2 = 1: 8.

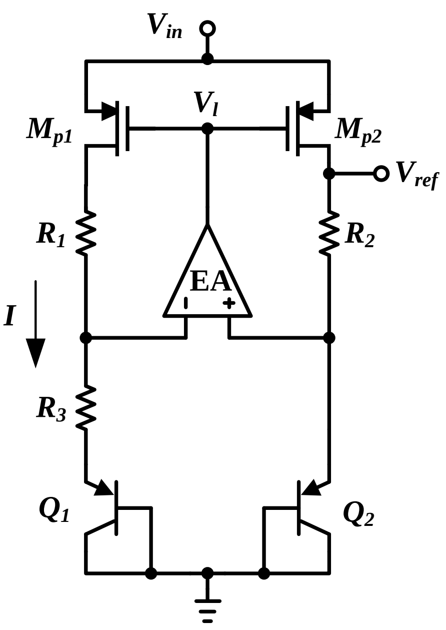

Fig. 1 Schematic diagram of reference voltage source with band-gap reference

When the error amplifier EA[7,8] works in the depth negative feedback, it can be known from the concept of "virtual short" that the positive and negative terminals of the EA have the same potential.

$$V_{EB2} = V_{EB1} + R_3 I \tag{1}$$

The v-i characteristic of the PN junction of the transistor is

$$I_e \approx I_c = I_s \frac{V_{EB}}{V_T} \tag{2}$$

Where, V_T is the voltage equivalent of temperature, expressed as

$$V_T = \frac{kT}{q} \tag{3}$$

From equations (1), (2) and (3)

$$I = \frac{V_{EB2} - V_{EB1}}{R_3} = \frac{V_T \ln N}{R_3} \tag{4}$$

By substituting equation (4) into equation (1), the output voltage expression of the band-gap reference voltage source can be obtained.

$$V_{ref} = V_T \ln N \frac{R_2}{R_3} + V_{EB2} \tag{5}$$

In type (5), the temperature of the equivalent voltage V_T is positive temperature coefficient, and V_{EB2} negative temperature coefficient, which can properly adjust the coefficient of V_T, namely regulating transistor Q_1 and Q_2 are the ratio of N, or change the proportion of resistance R_2 and R_3, finally make BGR V_{ref} output voltage for a constant output voltage has nothing to do with the temperature.

3. Numerical experiments

3.1 Analysis and Simulation of DC Characteristics

3.1.1 Temperature Characteristics of a Band-gap Reference Voltage Source

As can be seen from Fig.2, when the temperature of the band-gap reference voltage source designed in this paper changes from -35°C to 85°C, the output reference voltage V_{ref} changes by about 2.22mV and the temperature coefficient is about 15.3ppm/°C.

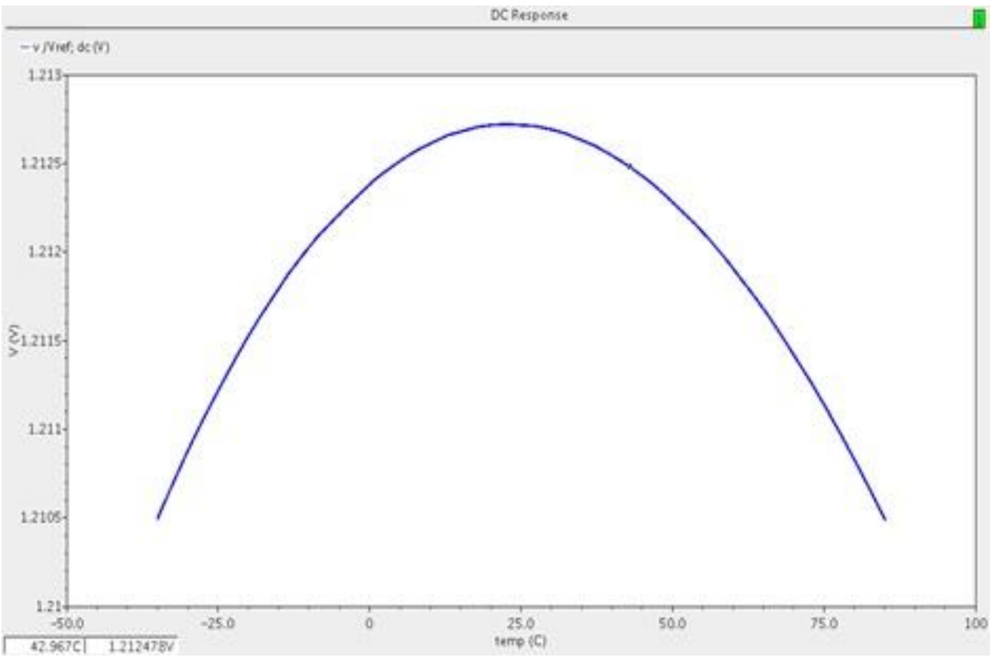

Fig. 2 Temperature characteristics of reference voltage source with band-gap reference

3.1.2 Linear Adjustment Rate of Band-gap Reference Voltage Source

As can be seen from Fig. 3, when the input voltage Vin changes from 3V to 6V, the output reference voltage Vref changes about 275μV, with a linear adjustment rate of 75.6ppm /V.

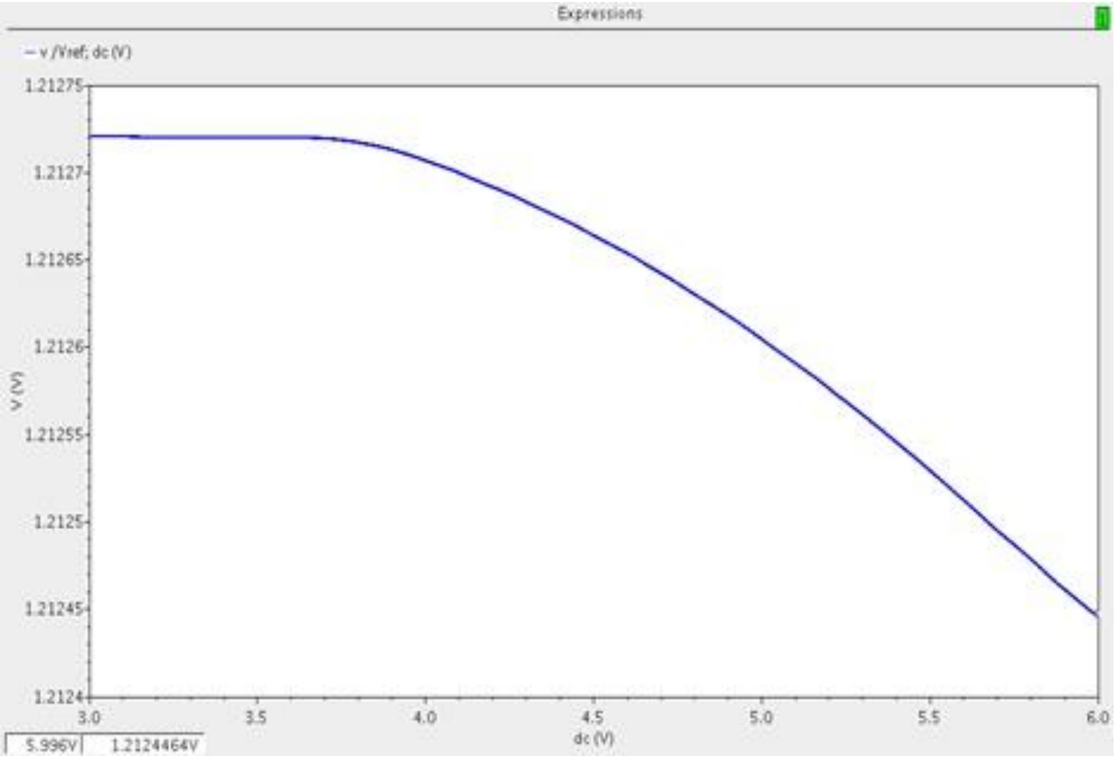

Fig. 3 Linear adjustment rate of band-gap reference voltage source

3.2 Analysis and Simulation of Rransient (TRAN) Characteristics

Startup Time of the band-gap reference voltage source refers to the Time that the input voltage V_{in} jumps from 0V to 3.3v after 1 s of rising time, and the output reference voltage V_{ref} experiences from jump to stable output. It can be seen from figure 5 that the starting time of the band-gap reference voltage source designed in this paper is about 1.1s.

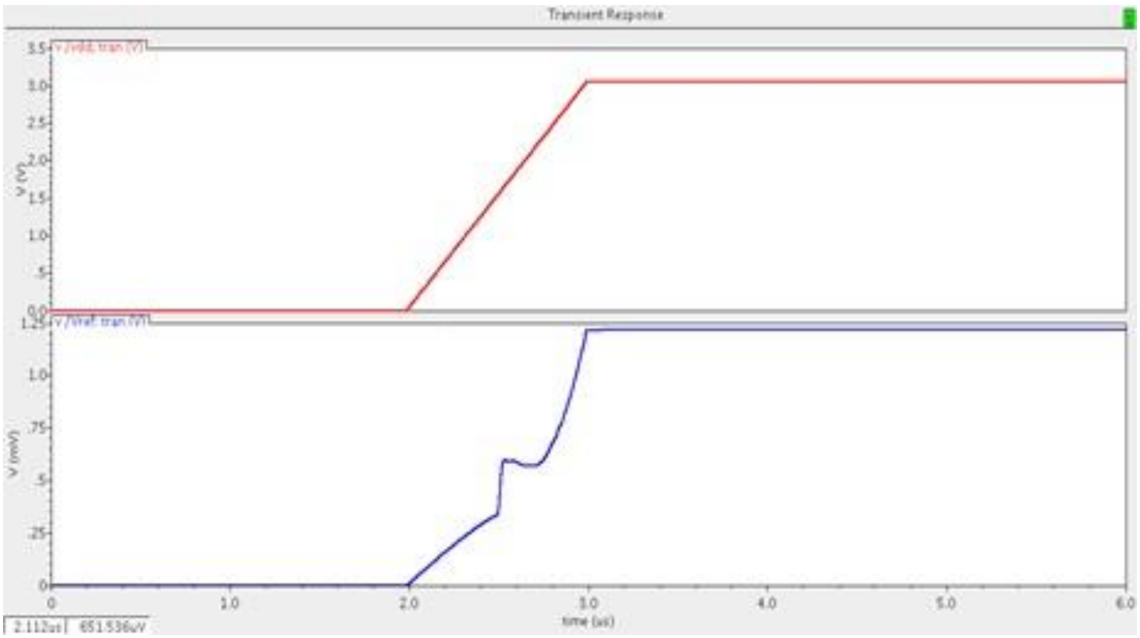

Fig. 4 starting time of the band-gap reference voltage source

4. Conclusion

The circuit structure of a reference voltage source and the circuit structure of its interference suppression capacity are designed. Using 0.35μm CMOS process to complete the design, and the reference voltage source performance simulation results, all indicators meet the design requirements.

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