# Design of Low voltage Bandgap Reference in 28nm Technology for Low power applications.

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***Abstract*— This paper presents the proposed design of Bandgap reference circuit which is well suited for low power applications. It works in both voltage mode as well as current mode. This design aims to provide an output voltage of 0.6 V with PSRR of 50 dB and temperature coefficient of 40 ppm/ºC in the temperature range of -40º to +125 ºC. This design will be implemented in 28 nm CMOS technology.**

***Keywords—Voltage reference, Bandgap reference, low power, PSRR***

## I. INTRODUCTION

Bandgap reference (BGR) is a source of precise voltage and is an integral part of any mixed signal design. BGR can work in both voltage mode and current mode. It should exhibit good static and dynamic performances. Static performance can be fine tuned with trimming on circuit. Dynamic performance must ensure constant voltage at output that is independent of process variations.

A typical BGR consists of 3 major blocks. Startup circuit, current source and load stage. As shown in figure 1.

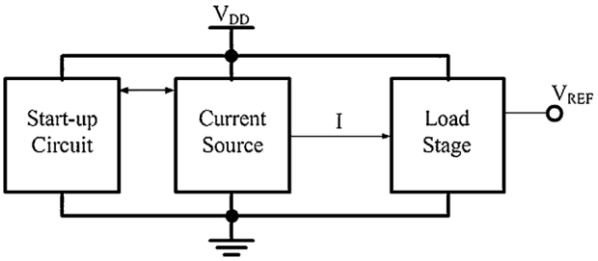


*Figure 1: Stages of Voltage reference*

A BGR is a circuit meant to generate exact reference which does not vary with respect to temperature, supply voltage fluctuation, process variations or load current. Design approach is to add the weighted voltages due to a current source proportional to absolute temperature (PTAT) and another which is having negative temperature coefficient (CTAT). Generally, these two current sources are built using bipolar junction transistors. The summation as given in equation (1) and (2) gives output voltage with respect to temperature which is referred to as compensated voltage with respect to temperature.

$$V_{ref}(\mathrm{T}) = V_{PTAT} m_1(T) + V_{CTAT} m_2(T) \qquad (1)$$

$$\frac{\delta V_{ref}}{\delta T} = m_1 \frac{\delta V_{PTAT}}{\delta T} + m_2 \frac{\delta V_{CTAT}}{\delta T} = 0 \qquad (2)$$

Over the years, BGR have been built using bipolar junction transistors. There have been fabrication issues when BJTs are implemented in CMOS technology. Also, BJTs need higher supply voltage and BGRs built using BJTs generate higher reference voltages along with occupying large area. Furthermore, BJTs in advanced technology nodes are unsuitable and hence an alternative was examined. MOSFETs in subthreshold region of operation exhibit BJT behaviors. CMOS current sources exhibit temperature sensitivity similar to that of BJTs and suitable for low voltage reference circuits. This is most suitable BGR structure for low power applications.

Proposed BGR circuit is as shown in figure 2.

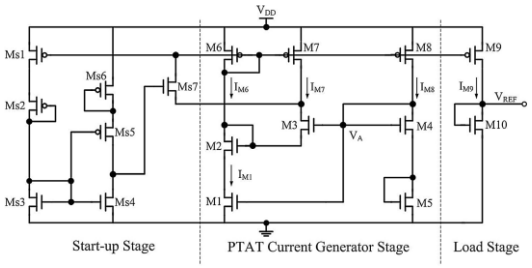


*Figure 2: Proposed design*

The proposed design as in figure 2 consists of current sources built using MOSFETs and load stage has MOSFETS of both types with high width and length to avoid the effect of process variations. The startup should trigger the operation of PTAT current course and turns off itself once normal operation is resumed. Figure 3 shows the schematic of the BGR using CMOS technology.

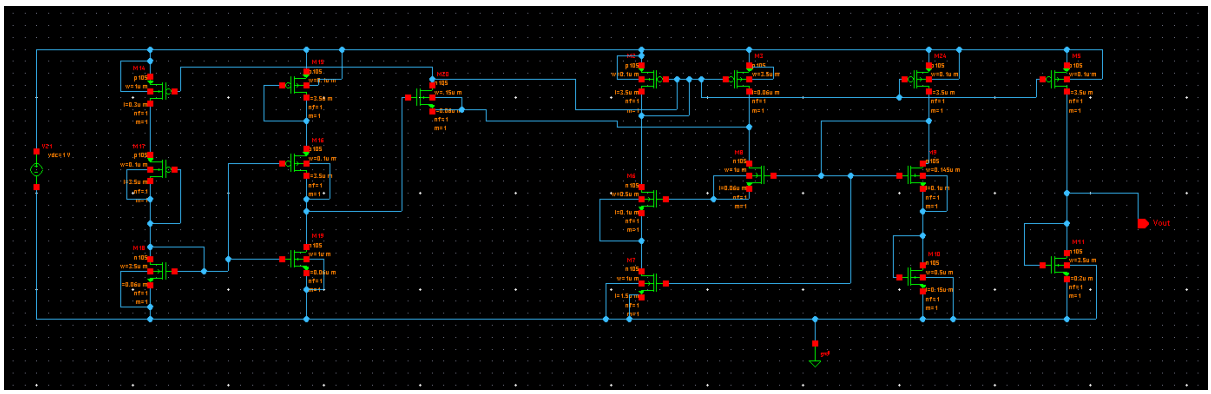

*Figure 3: Schematic of BGR*

Table 1 lists the performance parameters of the BGR design.

TABLE I. REFERENCE DESIGN SPECIFICATIONS

| **Parameters** | **Proposed design** |
|---|---|
| Output voltage | 0.3V |
| Supply voltage | 0.85V |
| Temperature range(°C) | -25 to +140 |
| PSRR | 32 dB |
| Temperature coefficient(ppm/°C) | 650 ppm |
| Power Consumption | 0.79$\mu W$ |
| Technolgy | 28 nm CMOS |

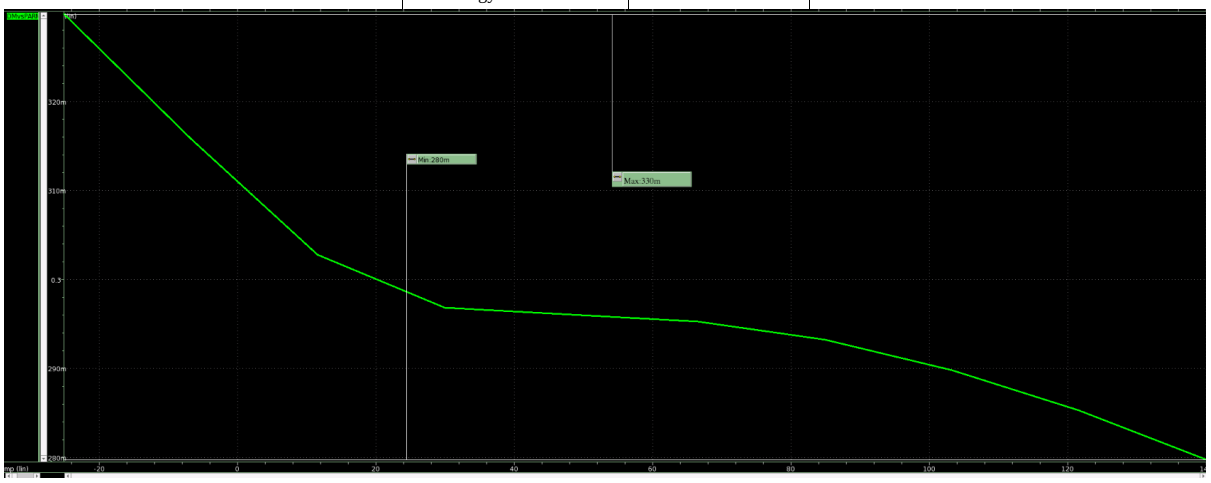


*Figure 4: Output voltage vs. temperature*

## References

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