

# Design of Simple Bandgap Reference circuit using Skywater 130 nm PDK

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**Abstract:** The growing influence of open source tools has necessitated introduction of open source PDK to eliminate barriers for individuals who have not access to commercial tools. In this paper we will discuss designing a simple Bandgap Reference circuit. A Bandgap Reference is a circuit which gives constant voltage output ( $V_{ref}$ ) irrespective of temperature and supply variations. It is an especially important component of several analog and mixed signal IC's. Several circuits such as LDO, ADC, DAC, Buck Converter, etc use Bandgap Reference as a building block. The circuit is simulated using Xschem, Ngspice and Skywater 130 nm PDK. The following paper shows the circuit details, diagram, waveform and references.

## 2. Reference Circuit Diagram

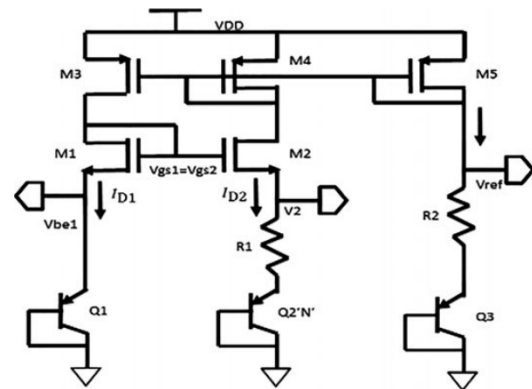


Figure 1: Reference Circuit Diagram. [1]

## 3. Reference Circuit Waveform

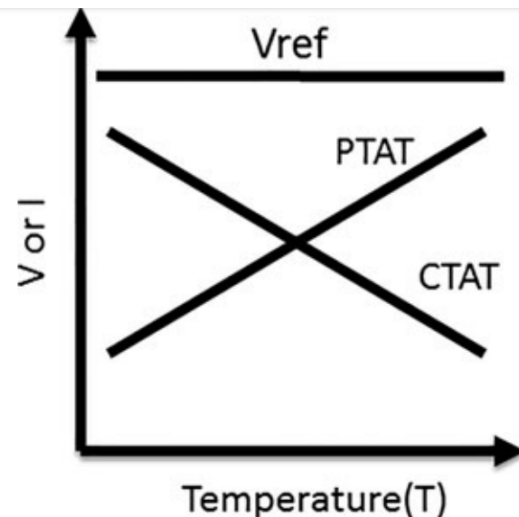


Figure 2: Reference Waveform. [1]

## 1. Reference Circuit Details

The main principle of Bandgap Reference is that The circuit is built with the basic analogy of canceling positive temperature coefficient which is PTAT and negative temperature coefficient which is CTAT that gives fixed voltage reference output independent of temperature and supply variations. As we know when we pass constant current through a diode the voltage across the diode ( $V_D$ ) decreases as temperature increases. This gives us our CTAT. For PTAT we take the voltage difference of 2 CTAT circuits. The circuit presented in this paper is self bias circuit where we have two PMOS for current mirroring and bottom two NMOS ensure constant voltage at point V2 and Vbe1. We want same and constant through both the branches so that we can get the correct PTAT and CTAT. We get Vref at the third branch where the current is mirrored using a PMOS.

## References

- [1] R. Akshaya and Siva Yellampalli Analysis and design of Bandgap Reference(BGR)
- [2] Youtube Videos - Analog Snippets
- [3]<https://www.vlsisystemdesign.com/analog-bandgap-sky130/>