General Purpose Bandgap Reference

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***Abstract*—This paper provides detail about General Purpose Bandgap Reference. The basic working principle of Bandgap reference circuits is explained . The circuit implementation is discussed and the issues with each implementation style is mentioned.**

***Index Terms*—Bandgap Reference, CTAT, PTAT, Current mirror, OpAmp.**

I. Introduction

A Bandgap Reference is a circuit which gives a constant voltage output V_{ref} irrespective of temperature, process and supply voltage variations. It is a very important component of several analog and mixed signal Integrated Circuits. A number of circuits such as LDO, ADC, DAC, Buck convertor, etc. use Bandgap reference as a building block. It provides a constant output reference voltage of 1.2V which is proportional to the Bandgap energy of Silicon (1.2eV) at 0K and hence, gets its name as Bandgap Reference circuit.

II. Principle Of Working

It is very difficult for any circuit to give a constant voltage output with varying temperature. To achieve our goal we would use two blocks of circuit namely CTAT and PTAT. CTAT block gives an output voltage which has a negative coefficient with temperature. PTAT block gives an output voltage which has a positive coefficient with temperature. The combination of CTAT and PTAT gives a constant voltage at the output.

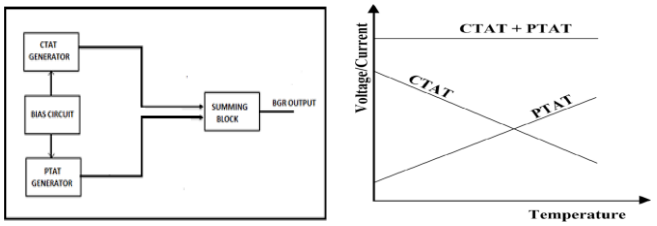

Fig. 1. The block diagram showing BGR(left) and the curves for generation of constant voltage at the output(right)[1] .

We should also be aware that any value of CTAT and PTAT will not be sufficient for the generation of constant output voltage at the output. The slope of the CTAT and PTAT should be opposite and equal in order for the circuit to work as intended. So, we multiply the curves with constants α_1 and α_2 to make them equal[2].

$$V_{ref} = \alpha_1 (CTAT) + \alpha_2 (PTAT) \qquad \text{..... (i)}$$

III. Circuit Implementation

The realization of Bandgap reference circuit requires a diode connected to a constant current source. The diode is formed by a bipolar junction transistor(BJT) with its base connected to its collector junction. The constant current source can be implemented using a current mirror or an OpAmp.

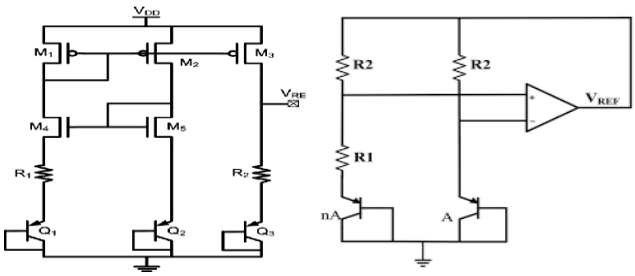

Fig. 2. BGR using current mirror(left)[1] and BGR using OpAmp(right)[3].

The current mirror arrangement shields the circuit from supply voltage variations but care must be taken while designing the current mirror such that equal current must flow through all branches, we can also use cascode current mirror circuit to ensure it. The OpAmp arrangement isolates the rest of the circuit from the supply voltage and so the variations in supply voltage are not reflected in the output. This arrangement can suffer from the limitations of the OpAmp used, such as offset voltage; it should be rectified within the circuit. A start up circuit is required for BGR to enter its normal state as during input transition it may end up in a zero current state. Start up circuit is active only when the BGR is in zero current state, it should turn off when the BGR is in normal state.

IV. Conclusion

Bandgap Reference circuit is an important analog block which is used for building different circuits. There are many circuit topologies present in research papers, all having their own advantages and disadvantages. The basic working principle is the same for all of them. The choice of a suitable circuit depends on the requirement of the overall system.

References

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