Applications of Band-Gap Reference in VLSI

Sheryl Corina Serrao

Department of Electronics Engineering, Fr. Conceicao Rodrigues College of Engineering
Mumbai, Maharashtra 400050, India

sherylcorina@gmail.com

***Abstract*— This paper discusses the applications of band-gap reference voltage in various Integrated circuits. It provides a broad overview of the applications and how their performance is affected by the band-gap reference voltage. An on-chip band-gap reference is a crucial block in the design of analog integrated circuits, as the accuracy and precision of these circuits can be limited by the reference voltage.**

***Keywords*—** band-gap reference; applications; performance; LDO; Data Converters; ADC; DAC

I. INTRODUCTION

The reference voltage, generated by the band-gap reference (BGR) circuit is immune to process, temperature, & supply voltage variations. BGR blocks are used in data converters-ADCs & DACs, LDOs, DRAMs, encoders & decoders, signal processing blocks, sensor interfaces, and several other applications. This paper restricts its discussion to three widely used applications of BGR voltage, namely: Low-dropout Regulators (LDOs), Data Converters: ADCs & DACs. The effect on performance of these applications due to BGR voltage is analysed further.

II. APPLICATIONS

The applications of band-gap reference voltage are briefly discussed and the influence on their performance due to the BGR voltage is studied.

A. Low-Dropout Regulator:

Low-dropout regulator is a DC linear voltage regulator that regulates the output voltage, despite the input supply voltage being very close to the output voltage. It has a higher efficiency compared to other DC-DC voltage regulators and buck converters. It has a wide array of applications, a few of them are listed: Phase Locked Loops (PLLs) , Clock and Data Recovery Circuits, High-Speed and High Accuracy Data Converters, etc. In order for proper regulation operation, the dropout voltage (V_{DO}), the minimum voltage difference between the input supply voltage and nominal output voltage must be maintained.

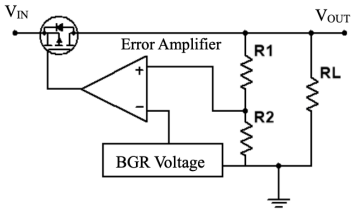

Fig. 1 Schematic Diagram of LDO

The LDO maintains a negative feedback control loop to regulate the output voltage to V_{ref}. The error amplifier senses the difference between the output voltage and V_{ref} and produces a gate voltage, modulating the resistance of the power transistor, producing a regulated output voltage. The BGR circuit is employed to generate V_{ref}.

Influence of BGR on LDO's performance: The BGR circuit contributes to the output noise of the LDO. As the BGR circuit has several active & passive components, any noise generated by the BGR or input ripple to the BGR will be amplified by the LDO's error amplifier, thereby, degrading the performance of the LDO.

B. Data Converters - ADCs:

Analog-to-Digital Converters convert analog signals to digital signals. ADCs are used in DSPs in mobiles, cameras, in data acquisition systems, etc. There are several architectures for realising ADCs, such as Dual slope, Successive Approximation, Flash type & Pipelined ADC. The reference voltage, used to set the range of conversion of the ADC is generated by the BGR circuit in the ADC.

Influence of BGR on ADC's performance: If the reference voltage generated is not stable over varying temperature and supply voltage, the output of the ADC will be skewed around the calibration temperature and voltage, producing inaccurate results. If the BGR circuit doesn't have noise value specifications lower than the ADC, it will affect the ADC's output code, thereby, deteriorating its accuracy and precision. The ADCs dynamic specifications such as signal-to-noise ratio (SNR), total harmonic distortion (THD) and spurious-free dynamic range (SFDR) will also be poorly affected.

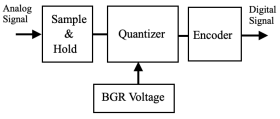

Fig. 2 Block Diagram of ADC

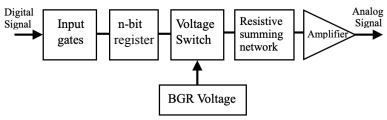

Fig. 3 Block Diagram of DAC

C. Data Converters - DACs:

Digital-to-Analog Converters convert digital signals to analog signals. DACs are used in audio/ image processing systems, in microcontrollers, in DSOs, signal generators, etc. The prominent architectures for realising DACs are, Binary weighted resistor DACs & R-2R Ladder DACs. The characteristics of a DAC are defined by its reference voltage, the BGR circuit is used to produce this reference voltage within the DAC.

Influence of BGR on DAC's performance: The influence of BGR on the DAC is similar to that on the ADC. Due to an unstable reference voltage, the full scale voltage, resolution and linearity of the DAC will be affected.Any noise on the BGR voltage causes a change in the converted analog output value, degrading performance.

III. CONCLUSION & FUTURE SCOPE

Therefore, from the aforementioned applications, it is evident that emphasis should be laid on the design of the BGR to ensure a high PSRR and a low temperature coefficient, as the BGR circuit is incorporated in a plethora of applications and a poor design could deteriorate the accuracy and precision of these applications.

IV. REFERENCES

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