A Wide Temperature Range with Low Power Voltage Bandgap Reference Circuit in 28nm CMOS Technology

Kashish Goyal, Jaypee Institute Of Information Technology, Noida

Abstract

A low power CMOS bandgap reference (BGR) circuit with low temperature coefficient is to be designed. BGR is used in Low dropout regulators and other DC to DC converters to compare any signal with the constant reference voltage which is supplied by BGR. The conventional bandgap reference circuit typically produces an output voltage of 1.2v that prevents the low voltage operation. A T-structure bandgap is the core circuit being used to design such a circuit that is capable of operating at lower supply voltage that can also provide low temperature coefficient of reference voltage (V_{REF}). V_{REF} is obtained from the sum of the two currents, one being proportional to V_{BE} and the other proportional to V_T. The proposed circuit consists of a CMOS opamp, BJTs and resistors and is designed in CMOS 28nm technology.

1. Circuit Details

The conventional BGR circuits are not useful for low voltage operation because in that circuit V_T increases linearly with temperature while V_{BE} decreases approximately linearly with temperature. For generating low temperature dependent $V_{REF,}$ both V_{BE} and V_T are summed along with the temperature scaling (K) factor and we get V_{REF} =1.2V, PTAT current generation loop is limited by the collector current structure of the BJT and the input common-mode voltage of the amplifier.

The technique used in this circuit lies in generating two currents; one proportional to V_{BE} which is minimum due to R_2 & R_3 resistors and the other proportional to V_T by only one feedback loop. In the proposed design the high gain operational amplifier with PMOS input differential pair is used to maintain equal node voltages and provide stable feedback to maintain the constant current that is independent of supply voltage variations. Stability of the OPAMP is achieved by using compensation capacitor and nulling resistor. The current flowing through M_{P1} , M_{P2} and M_{P3} are the same and therefore PMOS transistors should be of the same dimensions so $I_1 = I_2 = I_3$ and V_x=V_y by using a high gain amplifier. In the proposed equivalent T-circuit in bandgap core for calculating I_{2q} which has positive temperature coefficient proportional to V_{BE} and here I_3 is the sum of I_{2q} and I_{2p}. The negative temperature coefficient of current of the BGR circuit is reduced by big factor and then summed with positive temperature coefficient current resulting in low resistor value. Hence the overall voltage value is less compared to the conventional BGR circuit and other low voltage BGR circuits.

2. Circuit Design Schematic

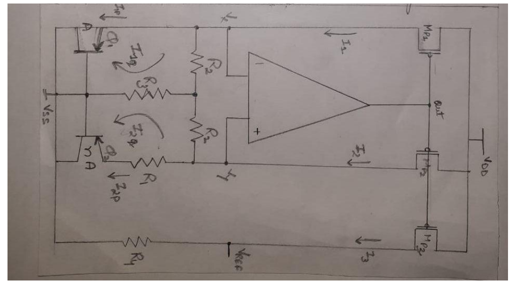

Figure 1: Schematic of low voltage BGR circuit

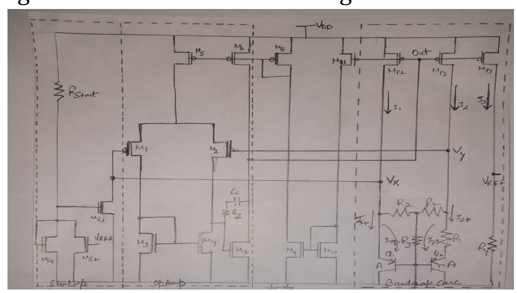

Figure 2: complete Schematic of low voltage BGR circuit

3. Schematic Results Waveform

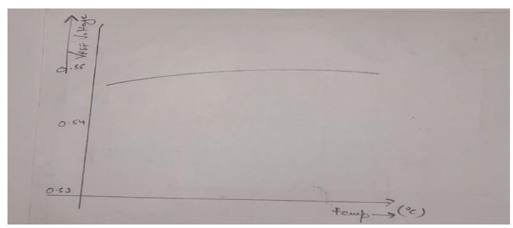

Figure 3: Output results of BGR

4. References Papers

1. H. Banba, H. Shiga, S. Umezawa, T. Miyaba, T.Tanzawa, S. Atsumi, K.Sakui, "A CMOS Bandgap Reference Circuit with Sub-1-V Operation," IEEE J. Solid-State Circuits, vol. 34, pp. 670–674, May 1999.
2. A. K. Singh, P. K. Pal, and M. Pattanaik, "A wide temperature range voltage bandgap reference generator in 32nm CMOS technology", in IEEE Global Conference on Communication Technologies (GCCT), pp. 696-699, 2015.
3. Adimulam, M. K., and K. K. Movva. "A low power CMOS current mode bandgap reference circuit with low temperature coefficient of output voltage," In Microelectronics and Electronics (PrimeAsia), 2012 Asia Pacific Conference on Postgraduate Research in, pp. 144-149. 2012