Characterization of Bandgap Reference Circuits designed for High Energy Physics Applications

F. De Canio[1,3], L. Gaioni[2], M. Manghisoni[2,3], S. Mattiazzo[3,4], L. Ratti[1,3], V. Re[2,3], E. Riceputi[2,3], G. Traversi[2,3]

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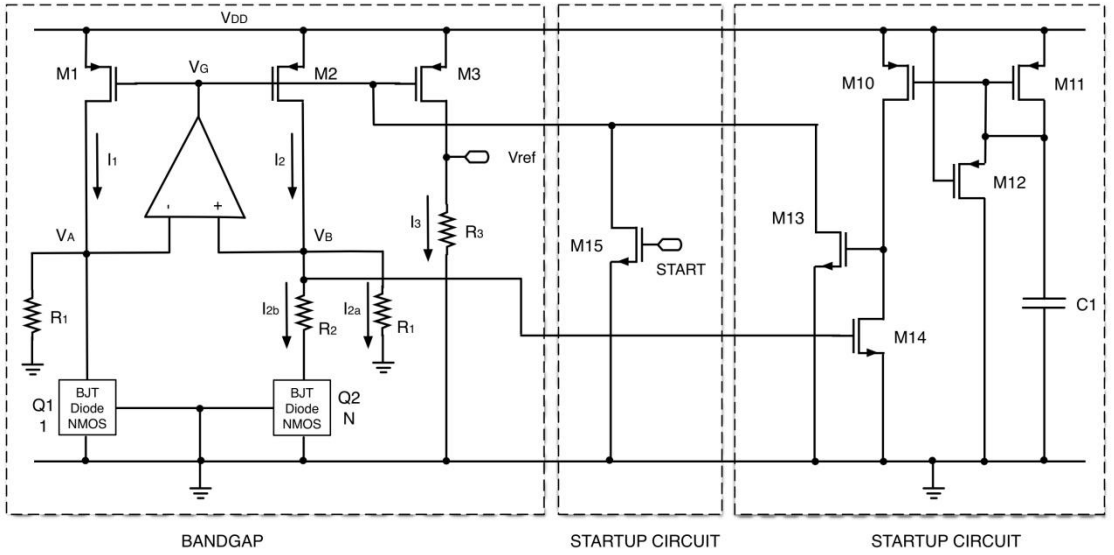
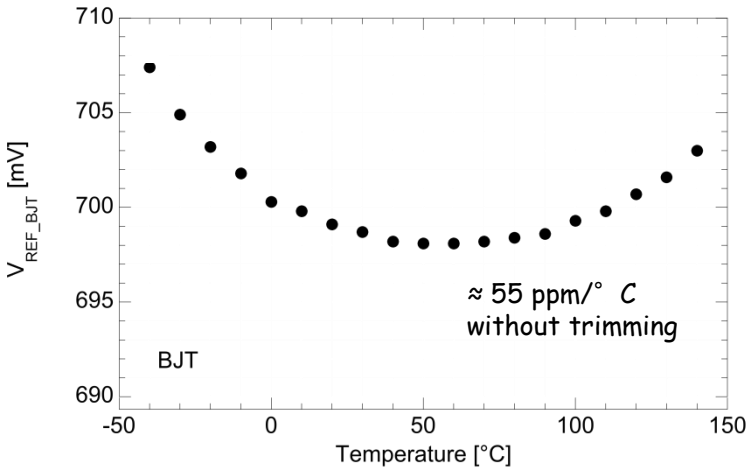
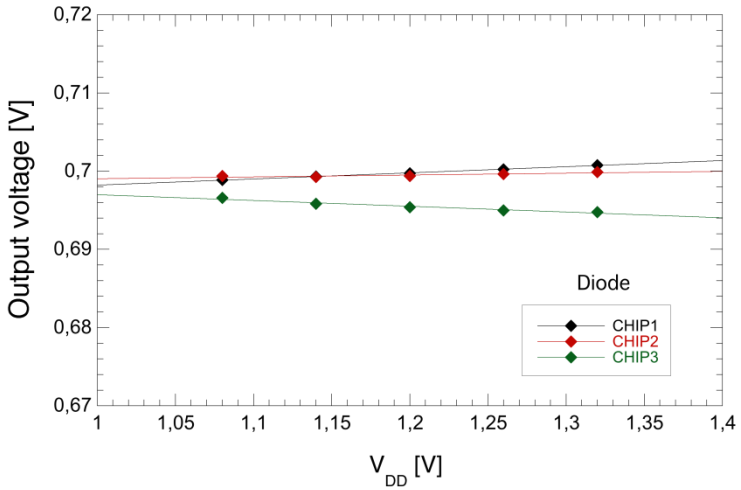
- A current mode bandgap reference circuit has been designed in a 65nm CMOS technology for a possible application in high energy physics experiments
- The prototype has been characterized as a function of temperature (from -30°C to +140°C) and voltage supply (from -0.78V to 1.32V) variation



Temperature variation



Voltage supply effect



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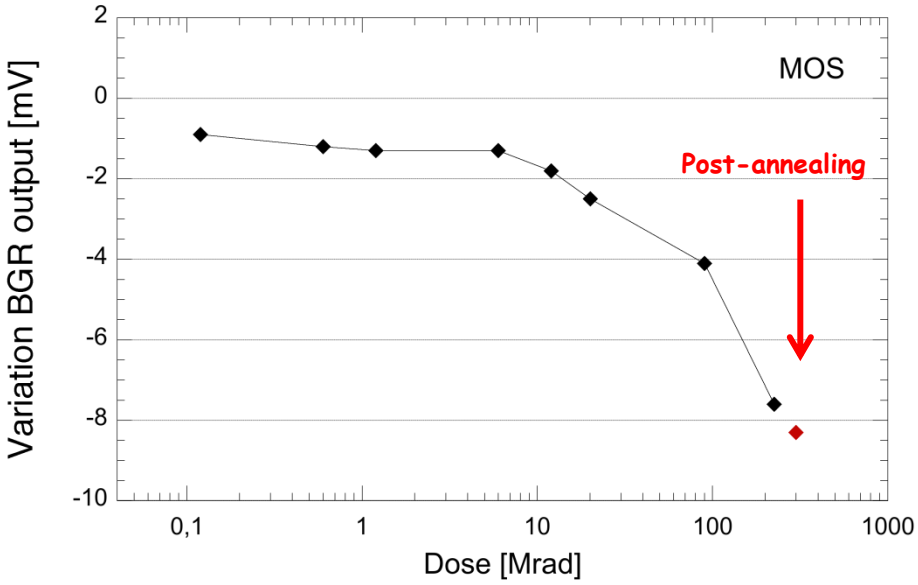
Due to the harsh environment foreseen for this circuit, different devices (BJT. Diodes, MOSFETs) have been considered and implemented in the prototype

BGRs have been irradiated up to 230Mrad (SiO_2) with X-rays:

- BGR based on BJT devices shows an increase of the output voltage from 690mV to 737mV: variation of 47mV. Recovers 6mV with Annealing (7 days at room temperature);
- BGR based on diode devices shows an increase of the output voltage from 706mV to 756mV: variation of 50mV. Recovers 6mV with Annealing (7 days at room temperature)
- BGR based on MOS in weak inversion region shows a decrease of the output voltage from 674.8mV to 667,2mV: variation of 7.6mV, degradation. Increase 0.7mV with Annealing (7 days at room temperature)



Promising result, but it has to be improved for some application (e.g. HL-LHC)

Conclusions and future activities

- A voltage shift around 0.6% was measured after irradiation up to about 100 Mrad (SiO_2)
- Irradiation with a monochromatic neutron source is being planned to study BGR sensitivity to bulk damage
- A different bias point of the circuit, featuring higher static currents, has to be used in order to improve the radiation hardness up to 1 Grad (RD53 requirement)
- A new design with trimmable resistance in order to reduce the temperature coefficient was designed