Contribution ID: **86** Type: **Poster**

A Radiation Tolerant Current Reference Circuit in a standard 0.13um CMOS Technology.

Thursday 18 September 2008 16:15 (20 minutes)

A Current-summing Bandgap reference circuit, has been developed in a 0.13um CMOS technology.
The reference current has low sensitivity to temperature and power supply variations.
In the design we utilize only CMOS structures (instead of diodes) and poly-silicon resistors.
The combination of the natural properties of the thin gate oxide MOS transistors with gate-all-around layout, results in a circuit having a very low susceptibility to ionizing radiation.
The output current varies in the range +- 0.9% when the circuit is being irradiated up to dose of 200 Mrad.

Summary

Integrated circuits with current comparators, A/D and D/A converters and bias circuits generally require reference currents with low sensitivity to temperature and power supply variations. For high-energy physics experiments an additional requirement is to deliver a stable current even when operating in ionizing radiation environments.
With the ongoing CMOS evolution, the gate-oxide thickness steadily decreases, resulting in an increased radiation tolerance of the MOS transistors. This, combined with special layout techniques, yields to circuits with a high inherent robustness against X-rays and other ionizing radiation. In bandgap voltage/current references, the dominant radiation susceptibility is then no longer associated with the MOS transistors, but is dominated by the diodes.
For this reason in the present design we excluded diodes and used instead new structures called dynamic-threshold MOS transistors (DTMOST). DTMOST is made of a standard p-channel MOST by means of tying the gate-, drain-, and bulk terminals together, whereas the source terminal is left open. This two-terminal device demonstrates an exponential (diode-like) current-to-voltage characteristic when the voltage is lower than 250mV. This feature enables us consider the DTMOST as a "low-voltage diode"and use it instead of ordinary diodes in standard bandgap circuits [1].
The present design has origins in current-summing bandgap reference circuit proposed by Banba [2]. This circuit delivers a stable current which can be used as a reference for current mirrors or can be converted into a stable voltage, if necessary.
The present circuit has four outputs providing currents of 2.5μA, 7.5uA, 16.5uA and 30uA.
The most important specifications are:
1) Power supply voltage is 1.0V⋯1.3V.
2) Output current-to-power supply voltage sensitivity is 10ppm/mV
3) Output current-to-the temperature sensitivity is
100ppm/ K (when trimmed) in the range from 0C to 40C
600ppm/ K (when untrimmed) in the range from 0C to 80C

4) Channel-to-channel spread of the absolute value of the output current is 7%.
5) Variation of the output current caused by ionizing radiation up to dose of 200 Mrad is +-0.9%.

[1] A. J. Annema , "Low-Power Bandgap References Featuring DTMOST's", IEEE J. Solid-State Circuits, vol.34, No.7, July 1999.
[2] H. Banba et al., "A CMOS Bandgap Reference Circuit with Sub-1-V Operation", IEEE J.Solid-State Circuits, vol.34, No.5, May 1999.

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Session Classification: POSTERS SESSION