Voltage reference for implantable medical devices

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Abstract – In this work an 1.05V voltage reference for implantable medical devices is presented. The reference consumes only 140nA with an area of 0.11um^2, while working with supply voltages from 1.8 to 4.2. The circuit was fabricated in the XC06 (06um) technology [1].

I. Introduction

In the last years there has been a great increase in the implantable devices market, which has been accompanied with an increase in research to reduce power consumption of different circuits. A precise voltage reference with minimum consumption is necessary for most applications (AD converters, stimulators, sensors etc. [2]). For implantable devices, temperature variations are very small (around 37C) but supply voltage may vary considerably from 1.8V to 4.2V depending in the batteries used and the state of the battery [3]. A low-power voltage reference was designed and fabricated in this work.

II. Design

The circuit of Figure 1 shows the designed reference voltage generator [4]. CMOS transistors T5A and T5B are designed to work in moderate inversion. The block formed by these transistors and the amplifier OTA (Operational transconductance Amplifier) are responsible for regulating the current so that is the same for both branches. D1 and D2 are bipolar transistors whose base and collector are connected to ground so as to function as diodes, but D2 is implemented with K=4 unitary transistors, while D1 with only one. The resistor was selected of 600kohm and the factor L=13.3 which gives a consumption of 120 nA.

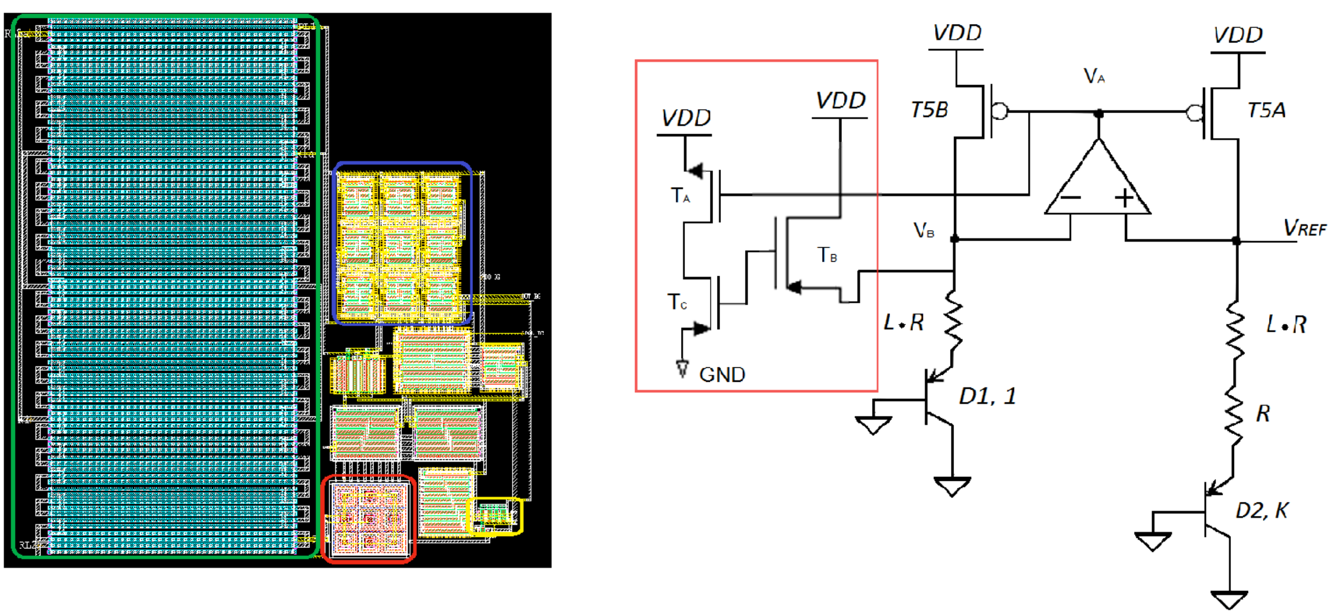

Fig. 1. Voltage reference layout and schematic. On the right is the schematic including the start-up circuit in red. On the left is the layout. Boxed in yellow is the start up, in red are the bipolar transistors, T5 CMOS pair in blue and the resistances are in green.

The OTA was implemented using the standard symmetrical circuit and is responsible for regulating the current through the main circuit branches. The differential pair transistors work in weak inversion for a low noise level at the input. The consumption of this block is just 5nA.

For the reference circuit to starts functioning properly a Start Up circuit is needed. This circuit injects a small current to one of the branches. This injection is enough to make this block work. There is a trade off between consumption of the Start Up circuit and the time it takes to stabilize. In this case, priority was given to reduce consumption (5.11 nA) keeping the starting time of a few tens of milliseconds.

In Figure 1 the layout of the complete circuit is shown. To reduce mismatch effects all CMOS transistors, the resistance and the bipolar transistors were implemented with smaller units interlaced, with dummy units in the edges. The resistors are of W=3um (minimum size) and L=464um for R. The resistors constitute 62% of total circuit area.

III. Simulations

In Figure 2 on the left side the reference voltage output under the influence of Start Up. The time taken to reach steady state is 23ms. Furthermore, on the right, the circuit response when it is supplied with sources ranging from 0 to 4.5V. From 1.8V the required reference voltage is achieved.

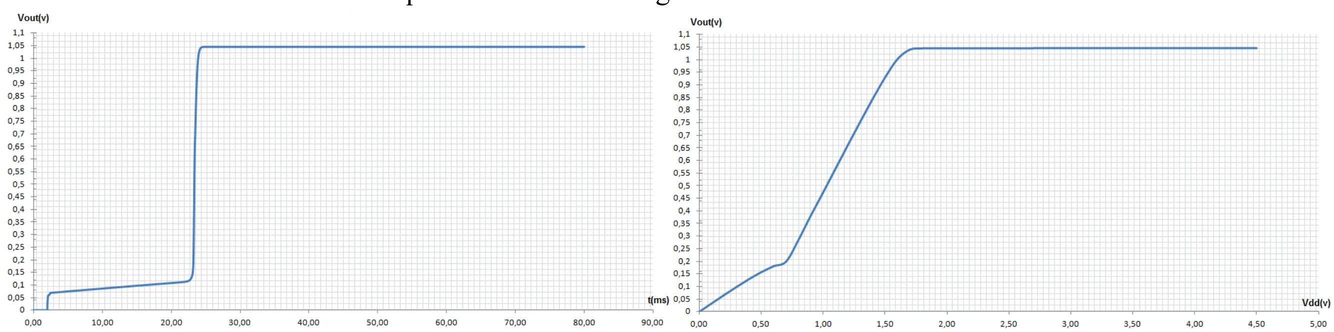

Fig. 2. On the left, output voltage vs. time. On the right, output voltage vs. supply voltage. Note that the circuit functions correctly after 23ms and works correctly for supply voltages greater than 1.8V.

IV. Conclusions

A low-power, 1.05V voltage reference was designed and fabricated, which complies with all requirements. The circuit provides an stable reference for supply voltages between 1.8V and 4.2V and temperatures from 27C and 47C. The voltage varies less than 1% for worst cases. Total silicon area is 0.12mm^2 in addition to a 0.05mm^2 output buffer for measurement purposes. The circuit is currently being fabricated and will be measured soon. Further works include introducing the autozero technique to the gm, to reduce offset and improve precision.

V. References

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