NFC Sensor Tag Development Using Industrial Flexible Integrated Circuit Process

การพัฒนาเอนเอฟซีเซ็นเซอร์แท็กด้วยเทคโนโลยีการผลิตวงจรรวมยืดหยุ่น

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Introduction

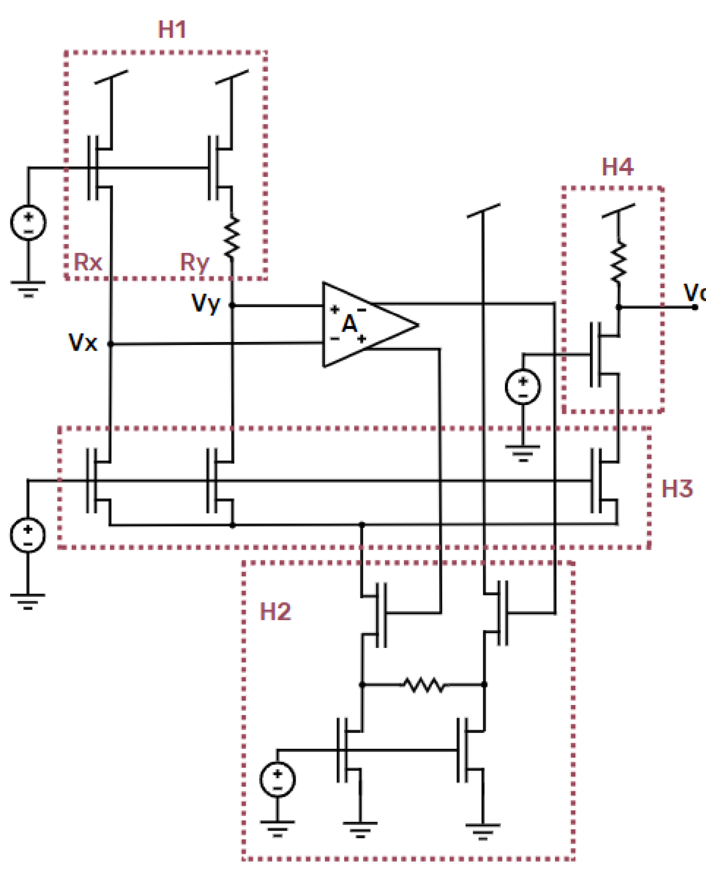
The electronics industry has changed significantly in the past few years, along with the growing trend on the Internet of Things. Flexible electronic circuits are very suitable for making wearable devices with sensors for measurement as needed.

We research and design an NFC sensor tag to test the circuit's potential in terms of performance and find the possibility to reproduce some circuits in mainstream process.

Scope of work : Study and design an NFC tag using Cadence Virtuoso software, which includes developing low-power digital components compared to reference research and developing temperature sensors capable of operating in the linear range.

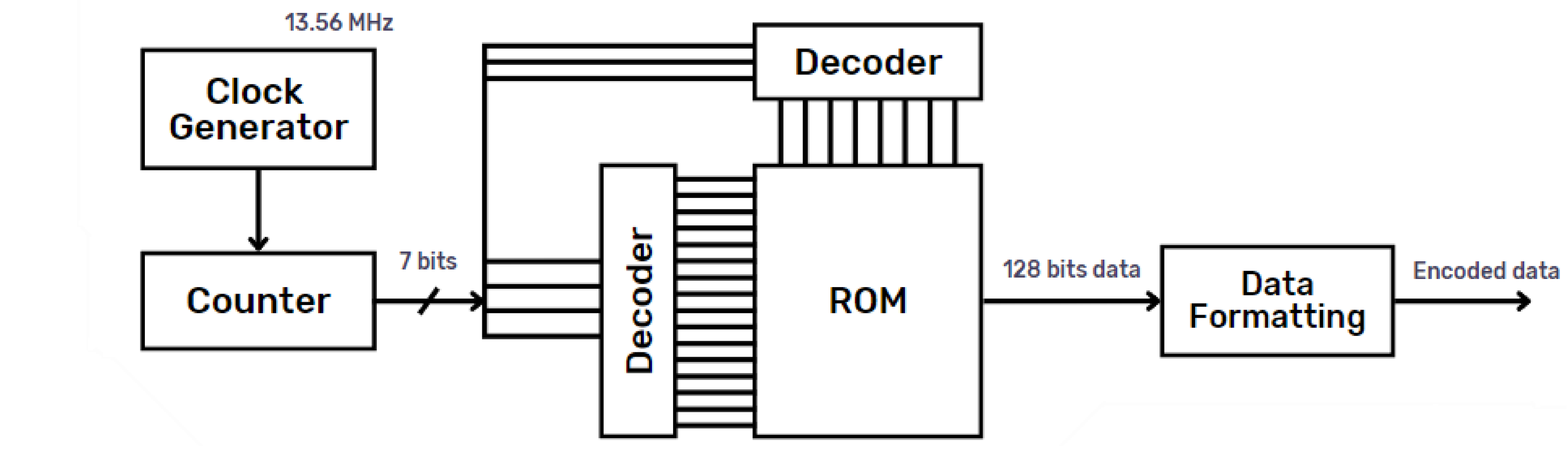
Temperature Sensor

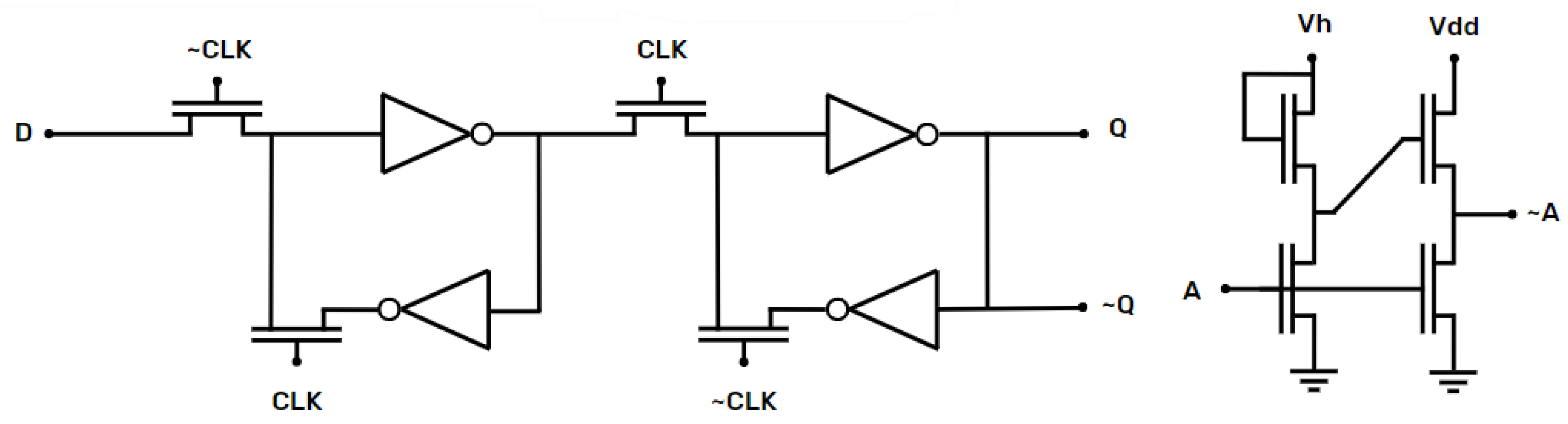
Firstly, the subthreshold operational region is employed to bring sensitivity out of H1, using current of proportional to absolute temperature (PTAT) in order to force voltage node of x and y to be equal by using negative feedback. The differential voltage between those two nodes is then transmitted to a differential output OPAMP(operational amplifier). the OPAMP are then biased to H2, where the differential voltage is converted into a single-ended current.



Using The feedback current splitting of H3 is utilized to maintain system stability in the face of temperature variations, with the current from H2 controlling this feedback loop. Finally, H4 uses one branch of this current to generate an output voltage that is proportional to absolute temperature.

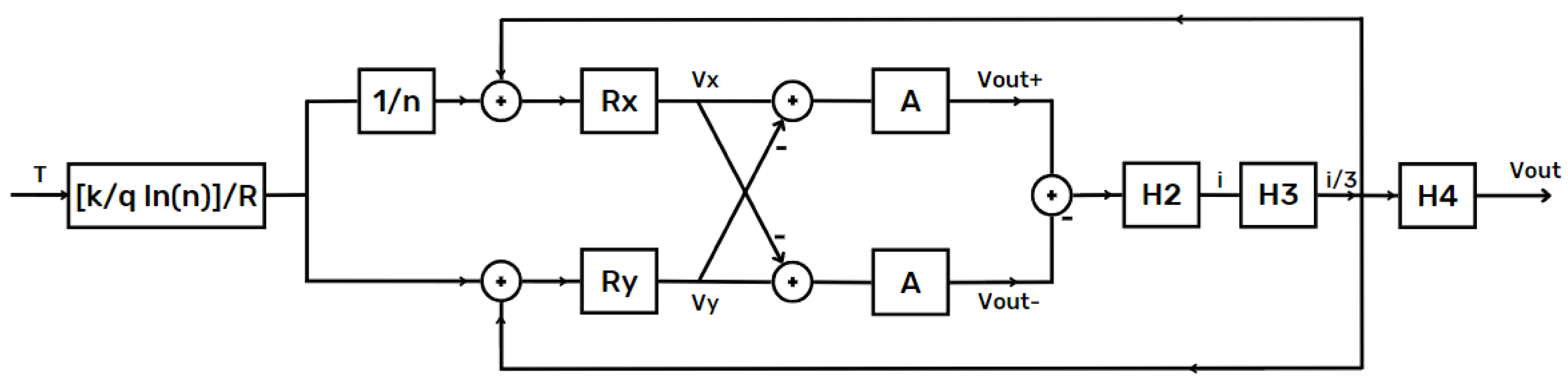
Block Diagram of Digital Core Generator





The clock generator receives frequency from the NFC reader and generates a clock that is divided for use in other parts. Then, a 7-bit counter uses divider frequency to count and sends a 7-bit count to each decoder. Next, read-only memory (ROM) transfers the data, bit by bit, into series code using decoders that indicate the address of each bit in ROM. Finally, the data sent out from ROM is formatted by the data formatting block using the principle of Manchester encoding due to its benefits. For example, self-clocking, DC balancing, and better error detection. However, because of the unipolar nature of transistors, the design is different from traditional CMOS processes. The figure shows the schematic of a D-flip-flop using a pseudo-CMOS diode-connected load instead of a P-type transistor in an inverter.

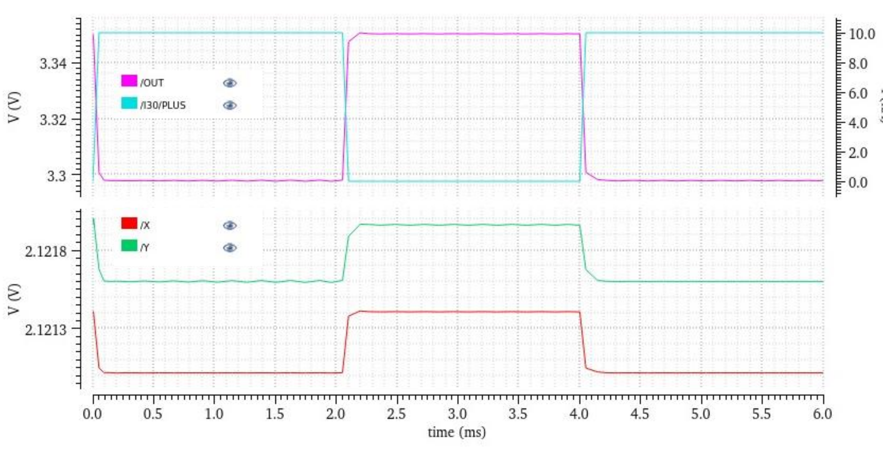
Block Diagram of Temperature Sensor



Result

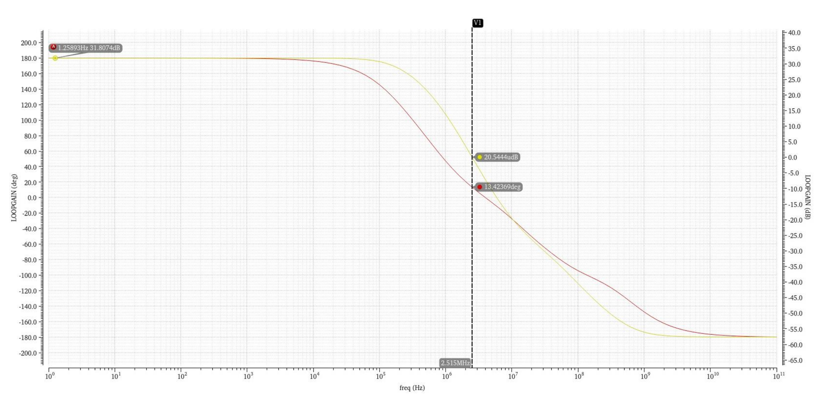
Stability

Transient response shows how system adjusts itself to remain stable after injects step current from zero to constant value in a very short time into system while the voltage at node V_x and V_y change.



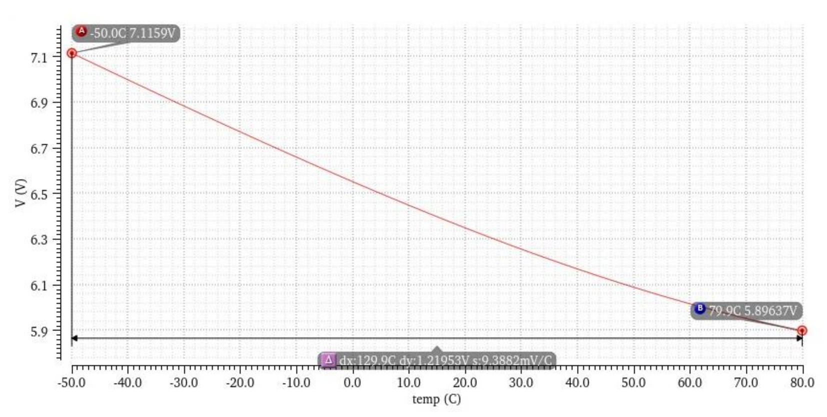
Frequency response

This is frequency response of loop L(s) which is considered as stability of these system. It have phase margin at 64, DC GAIN at 29.8 dB and Crossover frequency at 59 kHz.



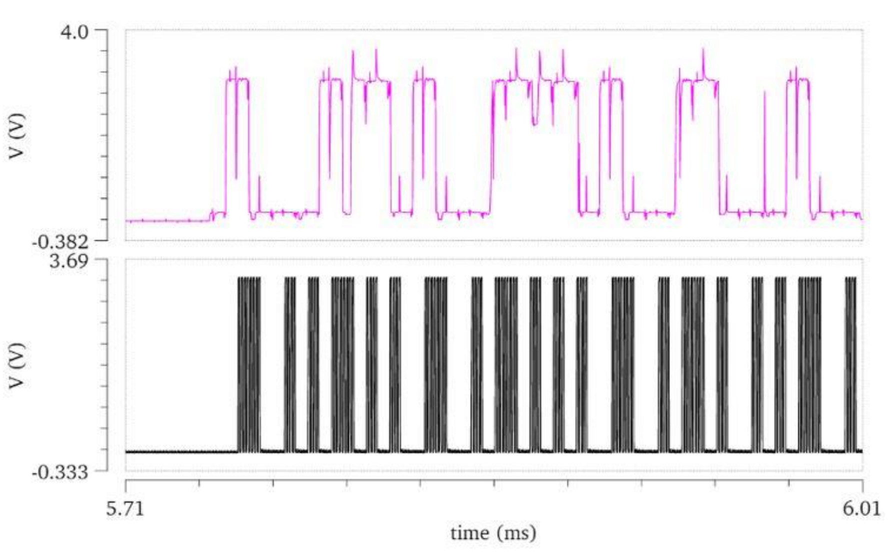
Sensitivity

This system operates at -50 to 80 degree Celsius. There is a sensitivity at 9.39 mV/Celsius.

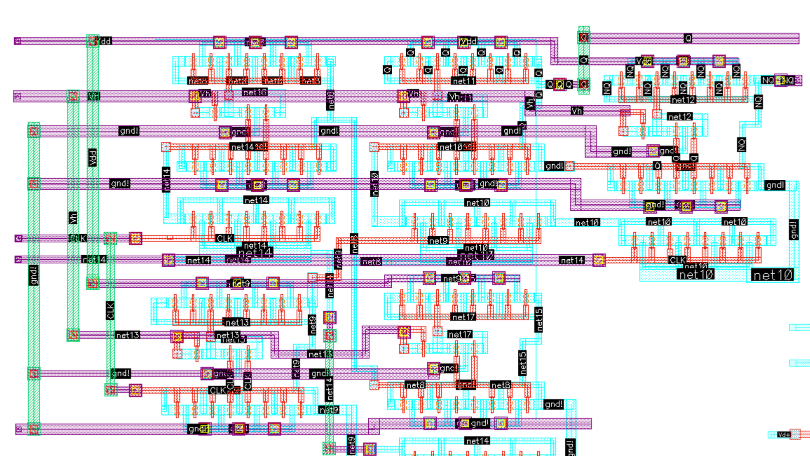


Digital Output Code

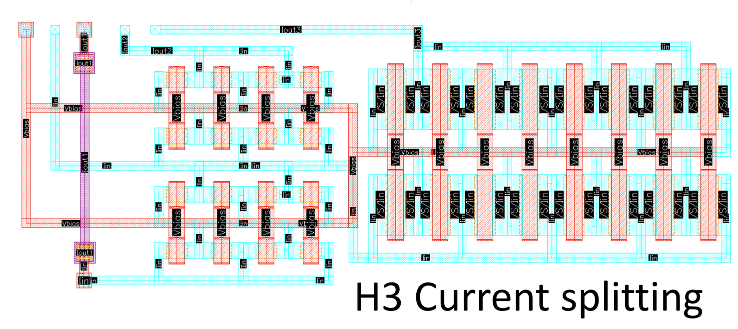
The system consumes 5 mW of power, which is considered lower than other works while clearly generating 128-bit code. According to the power gating method for reducing the static power, which is the main power dissipation.



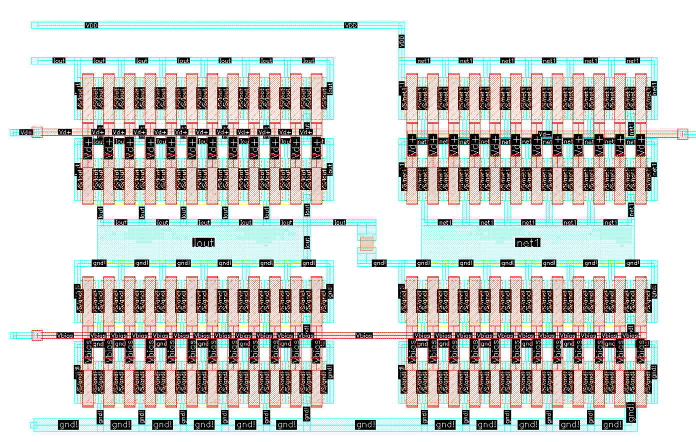
Layout



D Flip-Flop



H3 Current splitting



H2 current controlled feedback

Using DRC and LVM rule to check correction of the system.

Reference

K. Myny, "A Flexible ISO14443-A Compliant 7.5 mW 128b Metal-Oxide NFC barcode Tag with Direct Clock Division Circuit from 13.56 MHz Carrier, " in IEEE International Solid-State Circuits Conference, 2017 [3:7-8, 17-23]
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K. S. Szajda, C. G. Sodini and H. F. Bowman, "A low noise, high resolution silicon temperature sensor," in IEEE Journal of Solid-State Circuits, vol. 31, no. 9, pp. 1308-1313, Sept. 1996, doi: 10.1109/4.535415.