A Study on the Design of a Current Type ROIC for Uncooled Bolometer Thermal Image Sensor Using Correlated Double Sampling

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Abstract : In the presence of infrared light, a CMOS Readout IC (ROIC) for a microbolometer typed infrared sensor detects the voltage or current that is caused by the changing in resistance in the bolometer sensor. A serious problem in designing the ROIC is how the value of the bolometer and reference resistors vary because of variations in manufacturing process. Since different pixel have different resistance values, sensor operations must contend with fixed pattern noise (FPN) problems. In this paper, we propose a novel technique to compensate for the fluctuation in reference resistance by taking into account the process variation. By using constant current source basing and correlated double sampling, we solved FPN.

Key Words : ROIC, constant current source, correlated double sampling, fixed pattern noise

1. Introduction

The infrared light(IR) detectors used in infrared IR imaging systems can be classified into various categories, and others. A thermal effects image sensor, which uses thermal energy, has a lower sensitivity and, slower response than the photon effects image sensor which users photons of incident light, but it can be made easily and it is cheaper than other detectors because it does not need a cooling system. For this reason, IR image sensors that rely on thermal effects are used in a number of applications, including military and industry. Thermal effects detectors can be further classified as either bolometer types, which rely on charges in resistance caused by thermal absorption; thermopile types, which convert thermal energy into electrical energy, and pyro-electric types, whose electric polarization is changed by incident infrared radiation. Due to its ease of manufacture, the bolometer type detector os used in a variety of applications, and a few research groups are studying bolometer[1].

The electrical signal generated by a bolometer type detector is changed into more suitable signal through the use of a CMOS Readout IC (ROIC). Therefore, if one is to obtain high quality images, it is important to have an ROIC being highly efficient detector as well as being highly responsive and suitably linear[2].

In this paper, voltage mode 8X8 CMOS ROIC using constant current source was designed and studied for solving low responsibility of current mode. Also to remove fixed pattern noise (FPN) which is almost made by process variation we apply differential delta sampling (DDS) circuit to ROIC.

2. Circuit & Structure

Fig. 1 shows a block diagram of our proposed voltage mode 8X8 CMOS ROIC, which consists of main pixel array block which absorb IR energy, a reference pixel array block which don't absorb IR energy, a current source block for biasing pixel array by current, a correlated double sampling (CDS) block which samples the output voltage of the pixel array, a row decoder and column decoder block for sequential operating and outputting value to each pixel, and a variable gain amplifier (VGA) block which amplifies the small output voltage of the CDS block.

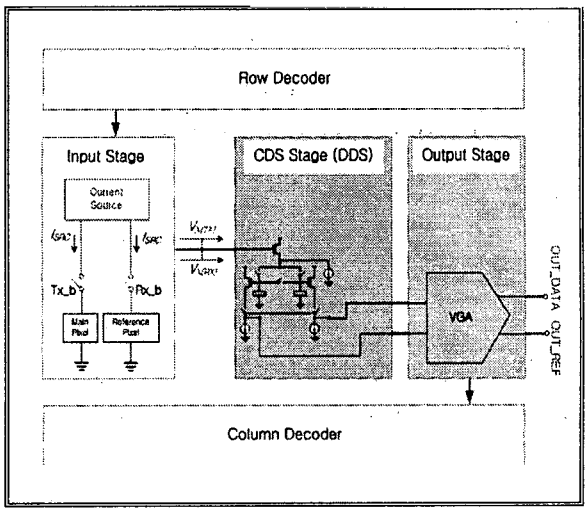

Fig. 1. Block diagram of proposed circuit.

3. Simulation & Results

We studied the operational properties and linearity of the output data of the proposed ROIC with HSPICE, which is used for circuit simulation. The simulation conditions shown in Table. 1 and the simulation results are shown in Fig. 2.

4. Conclusion

A bolometer sensor used in an infrared thermal imaging system does not need a separate cooling system, so manufacturing is easy. However, the sensitivity is low, the speed of operation is slow, and the FPN is greater than in an IR system with cooling. This paper offers a solution via our proposed ROIC.

Our proposed circuit used constant current type method, and DDS circuit to remove the mismatch noise of the ROIC itself, the FPN of the bolometer, and the reset noise in the CDS. Also, the proposed circuit not only used a constant current type readout method in a way that maximizes the circuit's sensitivity, but used fully differential amplifier with high DC gain and high frequency properties for a superior amplification factor and linearity in the VGA. As the result of simulation, the power consumption of the proposed readout circuit was about 2.42 mW and the linearity error rates was within ± 0.3 %.

Table 1. Simulation conditions for proposed circuit

Technology	0.18 μm, 3.3 V CMOS
TCR	-2.3 %
Main clock	8 kHz
VGA gain	64 times
Load capacitor	10 pF
Reference	400 $k\Omega$ @ 300 K
Bolometer	406 ~ 420 $k\Omega$ @ 2 $k\Omega$ Step

*TCR : Temperature coefficient of resistance

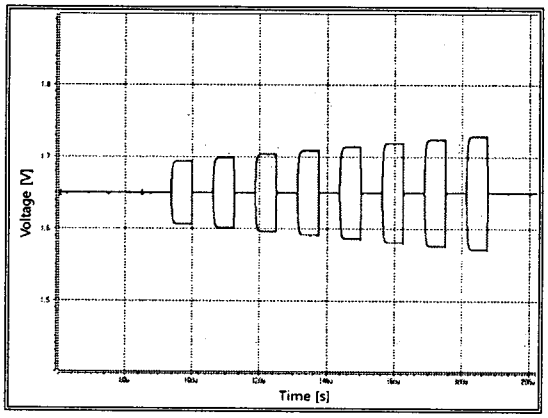

Fig. 2. Comparison of output wave

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