Design of Low Cost High Performance Uncooled Infrared Readout Integrated Circuit

V. Yuva Priya¹, M. Vilasini²

¹PG Student (M.E. VLSI Design), KPR Institute of Engineering and Technology, Coimbatore, India
²Assistant Professor, Department of Electronics and Communication Engineering, KPR Institute of Engineering and Technology, Coimbatore, India

Abstract—The infrared (IR) sensor market is developing rapidly and the microbolometer arrays are available for different applications. The improvement in the sensitivity and resolution of the sensor array leads to higher demands on the IR camera. A new approach for bolometer ROIC has been designed. This new approach for bolometer is based on high performance uncooled infrared readout integrated circuit (ROIC). The noise equivalent temperature difference (NEdT), the responsivity and power are the important parameters for uncooled infrared readout integrated circuit. This approach can reduce the system design complexities and improve the performance of uncooled bolometer system. This design of uncooled readout integrated circuit is implemented in microwind and it provides uniform output over a wide range of temperature. The performance of the uncooled infrared readout integrated circuit is higher. The resolution of the readout integrated circuit is increased and the output power is reduced.

Index Terms—bolometer, infrared (IR), noise equivalent temperature difference (NEdT), readout integrated circuit (ROIC)

I. INTRODUCTION

An infrared imaging system has a wide variety of technologies, such as infrared sensor manufacturing, image pattern recognition, analysis and processing algorithms. The emergence of uncooled detectors has opened new opportunities for infrared detection for both military and commercial applications due to their small size, less power consumption, and are less expensive, making these the ideal choice for applications.

The infrared radiation is sensed by the infrared detector as shown in Fig. 1. The readout circuit is an interface between infrared detectors and signal processing stages.

The Readout integrated circuits (ROICs) as shown in Fig. 2 serve as an interface between infrared sensor array and post-processing stages.

Fig.1 Infrared detector

Fig.2 Readout circuit

The block diagram of readout integrated circuit has rows and columns. The integration controller and the bias circuit are connected to the array. The pixel array senses the incident radiation and the infrared detector converts the radiation into electrical signal and the readout integrated circuit converts the electrical signal into the signal suitable for the processing. The detector used for converting the incident radiation into electrical signal has many cell arrays.
The readout circuit is composed of a row and column multiplexers controlled by a timing circuit. The detector signals are amplified and band limited by the readout circuit.

II. RELATED WORKS

R.K. Bhan et al., (2009) proposed the uncooled infrared microbolometer array and the characterization of microbolometer[2]. A. Rogalski (2009) gave the recent advances in the developments of the uncooled infrared detector technologies[8]. Sang Joon Hwang et al., (2010) proposed the readout integrated circuit for infrared image sensor application[3]. Joeri De Vos et al., (2011) in their work compared the different kinds of CMOS imagers and gave that for high end applications high performance fully hybrid imagers are the preferred option [7]. Jiawei Friedrich Xu et al., (2011) in their work proposed a design which provided improved performance compared to the conventional readout integrated circuit (ROIC)[1]. Eun Sik Jung et al.,(2012) proposed the readout integrated circuit which applies a fixed current bias sensing method to the input stage inorder to simplify the circuit structure and the infrared sensor characteristic control[5]. The image sensors are designed with different approaches in these works. The new approach for uncooled infrared readout integrated circuit (ROIC) is designed to provide high performance.

III. IMPLEMENTATION OF UNIT CELL IN MICROWIND AND DSCH

The main area of the chip is the identical sensors. The image data is sent out pixel by pixel to post-processing component using a row and column select block. Each pixel sensor is also called a unit cell. The circuit of the pixel sensor is implemented in DSCH2.

The circuit of the unit cell consists of the integration capacitance, shutter transistor, sample and hold capacitance and the column select. The integration capacitor is charged by the active low reset signal in the unit cell. The integration starts when the reset is turned off. The readout of the row of pixels is marked by the reset signal from the column select.

The circuit is implemented in DSCH. The verilog file is compiled in the microwind and the layout is obtained. The simulation provides the characteristics of voltage and time as default. The characteristics of voltage, current and time, static voltage and voltage, frequency and time are obtained.

This method is used for the design of the readout integrated circuit. The unit cell is first formed and using the unit cell the array of readout integrated circuit is formed. Then the resolution of the array is increased and the power is analyzed for the readout integrated circuit.

The implementation of unit cell in DSCH2 is given in Fig.3.

IV. IMPLEMENTATION OF ROIC ARRAY IN MICROWIND AND DSCH

The readout integrated circuit has pixel array made of rows and columns. For implementing the array, the unit cell is first implemented in the DSCH2. The pixel sensor array is then formed by connecting the unit cells in the form of array.

The circuit of 4x4 pixel sensor array is implemented in DSCH2 and is shown in Fig.5.
The layout and output characteristics of 4x4 pixel sensor array are obtained.

The characteristics of 4x4 pixel sensor array are shown in Fig.6.

When the temperature value is changed and the power gets altered. As the temperature is increased, the power decreases. The power at various conditions is observed based on the substrate temperature. The output characteristics are uniform over wide range of temperature.

The 4x4 pixel sensor array is now formed. The 4x4 array is now converted to a block. The block is shown in Fig.7.

The resolution can be increased by connecting this structure and the output characteristics are obtained and high performance is achieved.

When the array formed by connecting the structure is simulated the output characteristics are obtained.

The block of the 4x4 array are connected so that the 8x8, 16x16, 32x32, 64x64 and 128x128 array are formed. The resolution of the array is thus increased and the pixel sensor arrays are implemented.

The output characteristics of the 8x8 array are shown in Fig.8.

In this way the 16x16 array, 32x32 array, 64x64 array and 128x128 array are formed and the output characteristics are obtained.
V. RESULTS AND DISCUSSION

The 4x4 array block is connected and the 16x16 array, 32x32 array, 64x64 array and 128x128 array are formed. They are simulated in microwind and their output characteristics and the output power of the array are obtained.

The output power of the 128x128 array is 90.79µW. Thus the power is less.

The output characteristics of the 16x16 array are shown in Fig.9.

![Fig.9 Characteristics of 16x16 array](image1)

The output characteristics of the 32x32 array are shown in Fig.10.

![Fig.10 Characteristics of 32x32 array](image2)

The output characteristics of the 64x64 array are shown in Fig.11.

![Fig.11 Characteristics of 64x64 array](image3)

The output characteristics of the 128x128 array are shown in Fig.12.

![Fig.12 Characteristics of 128x128 array](image4)

VI. CONCLUSION

The new approach for bolometer ROIC is designed. This improves the performance of the uncooled bolometer system. The new design provides output characteristics over a wide range of substrate temperature for infrared detector array. When compared to the other approaches, this approach provides improved performance and the reduction in power. When the resolution of the array is increased, even though the size of the circuit increases, the power is reduced. In future, the element can be added suitably in the circuit of the pixel sensor array, so that the power is further reduced.
REFERENCES


V.Yuva Priya pursued B.E Electrical and Electronics Engineering in P.A.College of Engineering and Technology in 2012. She is currently doing M.E. VLSI Design in KPR Institute of Engineering and Technology.

M.Vilasini pursued B.E Electronics and Communication Engineering in 1999 and M.E in Government College of Technology in 2004. She is currently doing Ph.D in Anna University. Her research interests are image processing, satellite images and communication.