READOUT INTEGRATED CIRCUIT DESIGN FOR INFRARED DETECTOR WITH DUAL SWITCHED TYPE

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Abstract. This research designed a readout circuit with dual type switching for infrared sensors. The pixel readout circuit structure uses DI (direct injection) and CTIA (capacitive transimpedance amplifier). The readout circuit has four operating modes, which control single or dual band using signal control and the TSMC 0.35um 2P4M 5V process. The input current middle wavelength is set between 2nA to 4nA, the long wavelength is set between at 6nA to 8nA, the output voltage swing is 2.8V, and power consumption is 22.19mW.

Keywords: Direct Injection, Capacitive Transimpedance Amplifier, Readout Circuit.

Introduction

Research related to infrared imaging sensors in recent years compares the previous single-band infrared sensors readout circuit, which can detect a specific range of the infrared band [1,2]. The advantages of the dual-band infrared sensor readout circuit are improved environment tolerance, enhanced video signal, increased dynamic tracking range, and better contrast and brightness. Infrared sensors are susceptible to environmental noise impact of temperature, which results in resolution attenuation. The dual-band infrared sensor read circuit was developed by enhancing resolution, thus, it receives signals from a larger range and improves environmental noise tolerance to obtain the best signal.

This paper presents a 40x16 dual-band readout circuit with dual type switching for infrared sensors. The switch mode is used to achieve two types of pixel circuit transformation. The readout circuit has four operating modes due to the additional control signal. The first part of this paper provides a detailed description of the readout circuit structure and operation principles, the second part presents the results of the readout circuit simulation, while the final part offers conclusions and discussion for the circuit design.

Design of Dual Type Switching Readout Circuit

A. System Structure. The structure of the 40x16 infrared readout circuit system blocks is shown in Figure 1. The circuit system includes a switch for a dual type pixel circuit, a column stage circuit, a bias circuit, and an output stage circuit. The system structure is applicable to a single band or a dual band sensor. The middle wavelength of the dual band simulation input current setting is set between 2nA to 4nA, while the long wavelength is set between 6nA to 8nA. The 40x16 readout circuit is column interlaced.
B. Switch of Dual Type Pixel Readout Circuit. The structure of the dual type switching pixel readout circuit is as shown in Figure 2. Inside the unit pixel, there are two types of pixel circuit transformers, DI and CTIA[3,4], which are used with switches S1 and S2, respectively. When switch S1 is closed, the pixel readout circuit type is DI. The first circuit operated is reset by the INTR1 of MCN2. The charge is clear for CINT1. When the circuit is reset, it creates a fixed bias voltage for the photo current, which is sensed by the sensor as injected through MCp1, and the integration capacitor obtains the integration voltage. The current charge transfers to voltage according to equation (3.1). Obtain sampling voltage VSH by means of MCN3’s sampling. Finally, the signal selected by the ROW of MCp8 and the signal passes to the next stage for output.

When switch S2 is closed, the pixel readout circuit type is CTIA, and the first operated circuit is reset by INTR2 of MCp5. The charge is clear for CINT2. When the circuit is reset, the sensed photo current is injected through MCp5, and the integration capacitor obtains the integration voltage. The operating signal mode is sampled and passes to the next stage, as in the upside depiction

\[ V_{int} = \frac{I \times t}{C_{int}} \]
Simulation Result

The dual band readout circuit output simulation middle wavelength current is set between 2nA and 4nA, and the integration time is 250us, while the long wavelength current is set between 6nA and 8nA, and integration time is 125us. The readout circuit has four operating modes.

Fig.3 (a) shows the results of T1=0 and T2=0 mode simulations for the dual band DI mode. Fig.3 (b) shows the results of T1=1 and T2=1 mode simulations for the circuit operations of the dual band CTIA mode. Fig.3 (c) shows the results of T1=0 and T2=1 mode simulations of the circuit operations for dual band CTIA and DI modes. Fig.3 (d) shows the results of T1=1 and T2=0 mode simulations of the circuit operations for dual band DI and CTIA modes. Table.1 shows the Simulation result of dual type switching readout circuit, which operates at room temperature, with output swing of 2.8V, and power consumption of 22.19 mW.

![Fig.3 Simulation results of readout circuit with four operate modes.](image-url)
Table 1 Specifications for switch of dual type readout circuit

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Readout pixels</td>
<td>40×16 pixels</td>
</tr>
<tr>
<td>Technology</td>
<td>TSMC 0.35um 5V 2P4M</td>
</tr>
<tr>
<td>Input configuration</td>
<td>DI, CTIA</td>
</tr>
<tr>
<td>Power supply</td>
<td>5v</td>
</tr>
<tr>
<td>Maximum clock rate</td>
<td>3MHz</td>
</tr>
<tr>
<td>Output swing</td>
<td>1.6~4.4 v(2.8v)</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>22.19 mW</td>
</tr>
<tr>
<td>Input photo current</td>
<td>MWIR: 2.nA<del>4 nA; LWIR: 6nA</del>8nA</td>
</tr>
</tbody>
</table>

Conclusions

This study designed a single and dual band infrared sensor read circuit. The dual switching type readout circuit is used in the structure of a dual band read circuit, and includes two pixel control circuits, resulting in middle and long band circuits with independent controls to adjust integration time. The dual type switching readout circuit is selected for different types of pixel circuit architectures according to the switching circuit suitable for different sensor bias.

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References


