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Self-compensating method for bolometer–based IR focal plane arrays

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Abstract

We present a self-compensating system for fixed pattern noise reduction (FPNR) of focal plane arrays (FPAs) of infrared bolometer detectors. It is based on a first-order ΔΣ modulator serving as a non-saturating signal integrator. The demonstrated method suppresses both the effect of bolometer resistance due to non-uniformity across the FPA as well as the self-heating effect. The proposed system does not require any external or internal feedback loop for FPNR. This approach can be also used for other applications where a signal compensation is required.

Highlights

- First-order ΔΣ modulator serving as a non-saturating signal integrator
- The self-heating effect is rejected as the common mode
- ≈1000 × improvement in the readout amplitude of the bolometer signal
- System suitable for the ROIC for bolometer-based FPAs

Keywords

Bolometers, self-heating, infrared imaging, readout integrated circuit, sigma-delta modulation

I. INTRODUCTION

Infrared (IR) radiation in the wavelength range from 8 µm to14 µm is used in many applications such as astronomy, thermal scanning to search for people or animals, and recently very popular the preventive maintenance of electrical appliances and monitoring the thermal isolation of buildings. The emission of IR radiation can be detected by numerous methods. One of the early IR detectors was the Golay cell [1], where the incident IR radiation heated a medium inside its cavity, thus increasing its pressure. A flexible membrane expanded with the pressure and its expansion was monitored. It was an extremely sensitive IR detector, but unsuitable for integration into an array necessary for IR imaging. Later on, there was developed a photon detecting device based on large band gap semiconductors, such as HgCdTe [2]. This device is an excellent imager, but it requires cooling by the liquid nitrogen. Bolometers comprise a thermally isolated membrane integrated together with a temperature-sensitive device, most often a resistive temperature detector (RTD). The membrane warms up due to the incident radiation and the corresponding temperature change is then monitored. The first bolometer was developed in 1878 by astronomer S. P. Langley [3]. With the advent of integrated circuit technology and microelectromechanical systems (MEMS), focal plane arrays (FPAs) based on microbolometers were developed. The temperature sensing devices are typically RTDs composed of material with a high temperature coefficient of resistance (TCR). The resistors are typically made of metal, such as titanium [4], nickel [5], and platinum [6] or semiconductors, such as silicon, germanium [7], and vanadium oxide [8, 9].