

Memristor Based Readout Circuit for Infrared Spectrum Forest Fire Detection

By : Karthik K Singh and Rakeshkumar Mahto

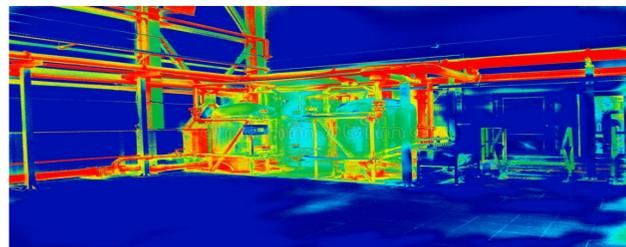
California State University, Fullerton

ABSTRACT

Forest fire caused lots of damage worldwide, resulting in destroying millions of forest land areas. According to recent statistics released by the California Department of Forestry and Fire Protection (CAL FIRE), in the year 2020, 8112 fire incidents were reported that resulted in damaging approximately 1.4 million acres of land in California. The IR based imaging camera required for this kind of application must be operable at ultralow power requirement, higher dynamic range, and high-performance focal plane array (FPA). Typically, an imaging system consists of FPA and a readout integrated circuit (ROIC). The FPA and ROIC circuit consist of sample and hold, integrator, and pixel selector circuit. The sample and hold stores the electrons generated when the photon incident on the pixel sensor. This is mainly done by using switching signals, capacitors, and MOSFET transistors. Once a particular pixel in the FPA is selected, the stored electrons across the capacitor are integrated. Later, ROIC is used to read the pixels' raw data and serially send them to an external computing device to further process captured image. The storing of the charges across the capacitor can leak the captured charges. Also, the serially sending of captured data to external computing devices requires high bandwidth and significantly increases power consumption.

Introduction

- As climate change is lurking as one of the biggest concerns to our planet, one of the most effective attributes of climate change is "Forest Fires". Forest fires have been continuously threatening our world as climate change is becoming more prominent and harming our environment.
- In this work we will discuss on how we can improve an ROIC of these IR cameras by implementation of MEMRISTORS. IR is a part of the electromagnetic spectrum that is invisible to the human eye, and its wavelength extends between 0.7 to 300 micrometers and a frequency range of approximately 1 to 430 THz.
- Using these IR cameras or thermal imaging cameras, we can detect wildfires and the range of the wildfires. The thermograms produced by the cameras will help us study the characteristics of the wildfires, which will, in turn, assist in combating the wildfires.



- The ROIC is responsible for the voltage conversion, timing and control circuits, pixel multiplexing and amplification stages in the camera. ROIC circuit consists of unit cells integrated into a silicon chip which acts as an interface between the FPA and the signal processing unit. The ROIC and FPA are connected via an array of indium bumps, which acts as an electrical interface between the two components.
- Memristor is a non-volatile electronic device that was first theorized by Leon Chau in 1971 as the fourth fundamental two-terminal circuit element following the resistor, capacitor and the inductor. The word "memristor" was coined from the contraction of memory and resistor. Ever since it was first theorized in 1971, the device was first implemented in hardware in 2008. The device was developed by R. Stanley Williams and several colleagues at Hewlett-Packard Laboratories

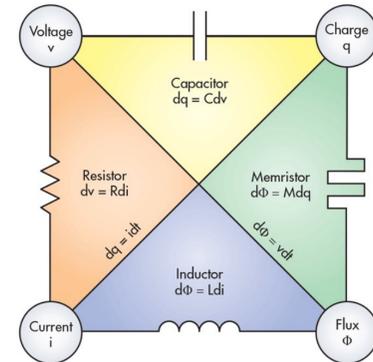


Figure 1. Memristor along with the three fundamental components.

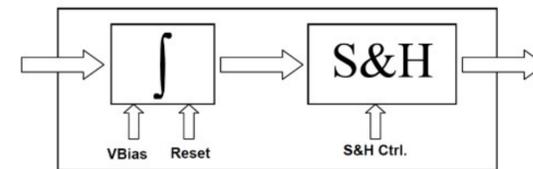


Figure 3. Simple representation of a unit cell

ROIC AND MEMRISTORS

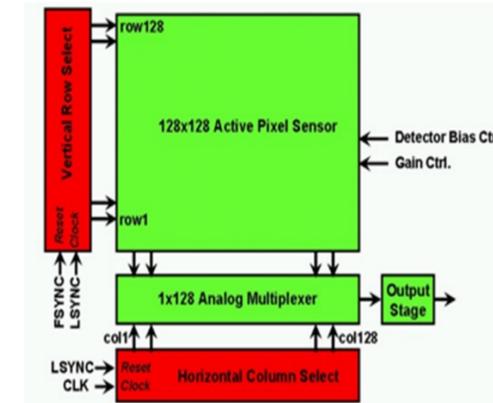


Figure 2. Block diagram of ROIC integrated circuit

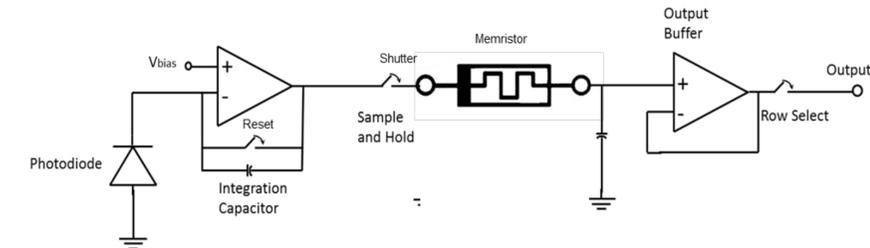


Figure 4. Circuit diagram of the unit cell

CONCLUSION AND FUTURE WORK

- A novel memristor based ROIC is presented in this work. The different key building blocks of ROIC and description of its functioning is presented in this work. The performance of different components and its proper functioning is tested using the SPICE simulation.
- In future, the layout of the complete ROIC circuit with memristor will be done. That way the proposed ROIC circuit can be compared with typical ROIC circuit in terms of area. Additionally, a major part of doing this research is to give ability to ROIC to compress an image at pixel level. This can be achieved by adding more transistors, capacitors or memristor with unit cell.

References

- S. N. Truong, K. V. Pham, W. Yang, and K. Min, "Memristor circuits and systems for future computing and bio-inspired information processing," in *2016 IEEE Biomedical Circuits and Systems Conference (BioCAS)*, Oct. 2016, pp. 456–459, doi: 10.1109/BioCAS.2016.7833830.
- S. M. A. B. Mokhtar and W. F. H. Abdullah, "Memristor-CMOS interfacing circuit SPICE model," in *2015 IEEE Symposium on Computer Applications Industrial Electronics (ISCAIE)*, Apr. 2015, pp. 147–150, doi: 10.1109/ISCAIE.2015.7298345.

SIMULATION

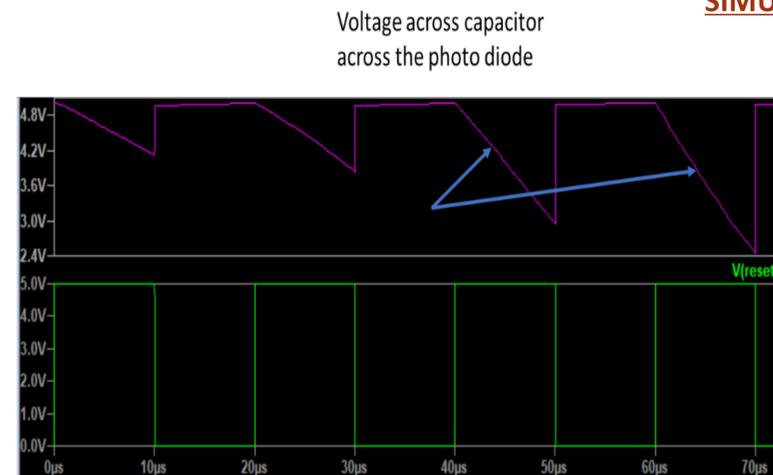


Figure 5. SPICE simulation of integrator

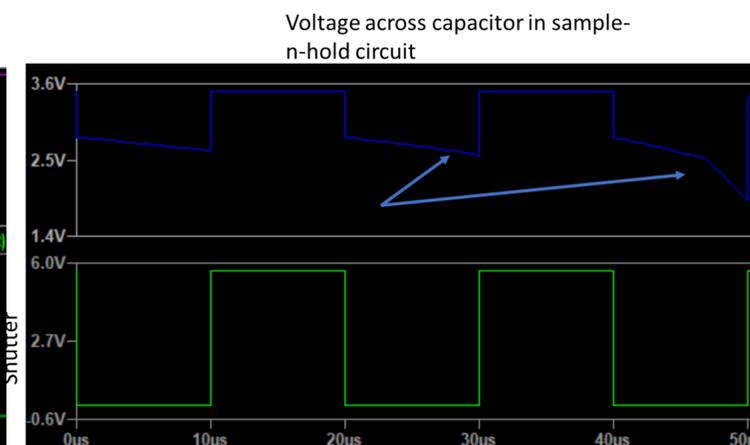


Figure 6. Transient analysis of the sample and hold circuit with the change in the shutter signal