Memristor Based Readout Circuit for Infrared Spectrum Forest Fire Detection

Kartik K Singh, and Rakeshkumar V Mahto
Computer Engineering Program, California State University, Fullerton, CA 92831

Abstract:

Forest fire caused lots of damage worldwide, resulting in destroying millions of forest land areas [1]. According to recent statistics released by the California Department of Forestry and Fire Protection (CAL FIRE), in the year 2020, 8112 fire incident were reported that resulted in damaging approximately 1.4 million acres of land in California [2]. Additionally, many person-hours and resources are devoted to suppressing these forest fires. Recently, CAL FIRE released an estimate that around $372 million are required to suppress forest fire in the years 2020-2021 [2]. These frequent forest fires are detrimental to the economy, environment, flora, and fauna of the affected area.

Due to the vast impact of the forest fire, many techniques are developed for detecting forest fires [3]–[5]. Some of the research towards fire detection suggested installing the manual tower, animal sensors [6], and UAVs [7]–[9]. These techniques become challenging for covering a vast area and, in some cases, can be considered unreliable. An Advanced Very High-Resolution Radiometer (AVHRR) based fire detection technique that uses satellites is used in past [10]. However, due to the distance between the forest and satellite, detecting incipient fire becomes almost impossible. The image collected by the satellite is required to be sent to the base station and then processed that results in the loss of several hours, by when the fire could have easily aggravated into an uncontrollable situation. Hence, a localized optical sensor that can identify the fire at early stages and notify the fire authority about them is an ideal technique in alleviating the damage caused by the forest fire [4]. It is presented in [4], infrared (IR), thermal imaging camera are ideal for such applications that can able to detect the extent the fire and IR spectrometers for recognizing the type of the smoke.

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) [11]. 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 circuit store 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 [12]. The storing of the charges across the capacitor can leak the captured charges [13]. Also, the serially sending of captured data to external computing devices requires high bandwidth and significantly increases power consumption.

This presentation shows a novel imaging system that improves the current ROIC circuit by using memristors. The use of memristors in the ROIC can prevent the leakage of the charge stored across the capacitor. Additionally, it can improve the operation and control of FPA by giving tunability to IR sensors. Moreover, memristors' use provides the ability to compress the image by applying various algorithms on the FPAs.

Reference:

[1] L. M. Ribeiro *et al.*, "2 - Extreme wildfires and disasters around the world: lessons to be learned," in *Extreme Wildfire Events and Disasters*, F. Tedim, V. Leone, and T. K. McGee, Eds. Elsevier, 2020, pp. 31–51.

[2] "Welcome to Stats & Events." https://www.fire.ca.gov/stats-events/ (accessed Dec. 30, 2020).

[3] M. Naderpour, H. M. Rizeei, N. Khakzad, and B. Pradhan, "Forest fire induced Natech risk assessment: A survey of geospatial technologies," *Reliab. Eng. Syst. Saf.*, vol. 191, p. 106558, Nov. 2019, doi: 10.1016/j.ress.2019.106558.

[4] A. A. A. Alkhatib, "A Review on Forest Fire Detection Techniques," *Int. J. Distrib. Sens. Netw.*, vol. 10, no. 3, p. 597368, Mar. 2014, doi: 10.1155/2014/597368.

[5] V. Chowdary and M. K. Gupta, "Automatic Forest Fire Detection and Monitoring Techniques: A Survey," in *Intelligent Communication, Control and Devices*, Singapore, 2018, pp. 1111–1117, doi: 10.1007/978-981-10-5903-2_116.

[6] Y. G. Sahin, "Animals as Mobile Biological Sensors for Forest Fire Detection," *Sensors*, vol. 7, no. 12, pp. 3084–3099, Dec. 2007.

[7] X. Yang, L. Tang, H. Wang, and X. He, "Early Detection of Forest Fire Based on Unmaned Aerial Vehicle Platform," in *2019 IEEE International Conference on Signal, Information and Data Processing (ICSIDP)*, Dec. 2019, pp. 1–4, doi: 10.1109/ICSIDP47821.2019.9173181.

[8] V. Sherstjuk, M. Zharikova, and I. Dorovskaja, "3D Fire Front Reconstruction in UAV-Based Forest-Fire Monitoring System," in *2020 IEEE Third International Conference on Data Stream Mining Processing (DSMP)*, Aug. 2020, pp. 243–248, doi: 10.1109/DSMP47368.2020.9204196.

[9] H. Dang-Ngoc and H. Nguyen-Trung, "Aerial Forest Fire Surveillance - Evaluation of Forest Fire Detection Model using Aerial Videos," in *2019 International Conference on Advanced Technologies for Communications (ATC)*, Oct. 2019, pp. 142–148, doi: 10.1109/ATC.2019.8924547.

[10] V. Cuomo, R. Lasaponara, and V. Tramutoli, “Evaluation of a new satellite-based method for forest fire detection,” *Int. J. Remote Sens.*, vol. 22, no. 9, pp. 1799–1826, Jan. 2001, doi: 10.1080/01431160120827.

[11] P. Zarkesh-Ha, “An intelligent readout circuit for infrared multispectral remote sensing,” in *2014 IEEE 57th International Midwest Symposium on Circuits and Systems (MWSCAS)*, Aug. 2014, pp. 153–156, doi: 10.1109/MWSCAS.2014.6908375.

[12] P. Zarkesh-Ha, W. Jang, P. Nguyen, A. Khoshakhlagh, and J. Xu, “A reconfigurable ROIC for integrated infrared spectral sensing,” in *2010 23rd Annual Meeting of the IEEE Photonics Society*, Nov. 2010, pp. 714–715, doi: 10.1109/PHOTONICS.2010.5699088.

[13] K. Ishida, K. Kanda, A. Tamtrakarn, H. Kawaguchi, and T. Sakurai, “Managing leakage in charge-based analog circuits with low-V/sub TH/ transistors by analog T-switch (AT-Switch) and super cut-off CMOS,” in *Digest of Technical Papers. 2005 Symposium on VLSI Circuits, 2005.*, Jun. 2005, pp. 122–125, doi: 10.1109/VLSIC.2005.1469348.