Infrared FPA Readout System with NIRCA MkII ASIC

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Abstract

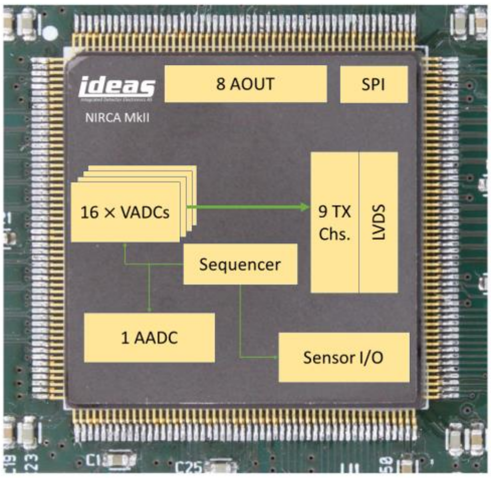
This paper describes the development of a focal plane array (FPA) readout system based on the NIRCA MkII application specific integrated circuit (ASIC). The system aims to reduce the size, weight, power, and cost of IR image sensor systems. We have developed NIRCA MkII and board-level electronics with NIRCA MkII at the center that allows users to connect FPAs and acquire data via Camera Link (CL) to their computers. The board-level electronics allows one to design instruments with NIRCA MkII packaged in 208-pin CQFP and qualified for flight. We describe the functionality and performance of NIRCA MkII with the board-level electronic system.

Background

Infrared (IR) image sensors are essential in astronomy and earth observation from space, where the detector performance can be the key limiting parameter. Continuous improvements and new developments are needed because the available detector technologies often do not meet the requirements specified by the science community [RD01]. IR image sensor systems consist of a radiation sensitive material, the readout integrated circuit (ROIC), a programmable controller and a video signal digitizer.

NIRCA MkII

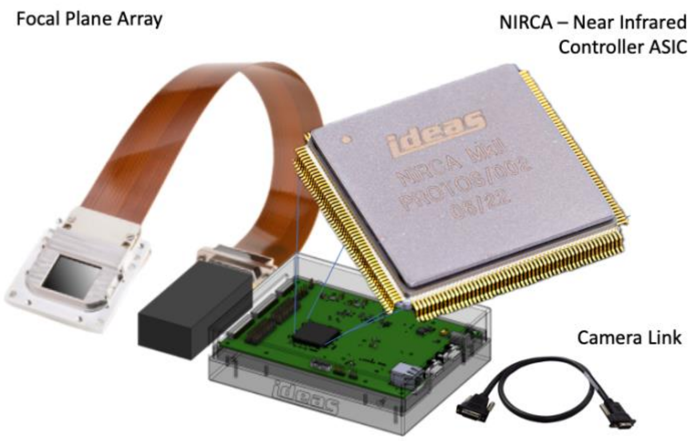
The Near Infrared Readout Controller ASIC (NIRCA MkII) has been developed for infrared detectors in Earth Observation and Astronomy [RD02]. The ASIC provides a single-chip solution for reading out analog signals from focal plane arrays (FPAs). FPAs typically comprise compound semiconductors hybridized onto a readout integrated circuit (ROIC) having one or more analog outputs. The NIRCA MkII amplifies and digitizes up to 16 analog signals and provides the clocked and timed signals as well as bias voltages needed for operating the FPAs. The figure illustrates the NIRCA MkII in CQFP208 with a block diagram and interfaces. The ASIC features 16 video channels, each consisting of a programmable gain amplifier (PGA) and a pipeline analog-to-digital converter (ADC). The ADCs have a 16-bit resolution with sampling speeds up to 12 Msps. NIRCA MkII accommodates a variety of analog signals by allowing input offset adjustment and providing eight gain options for PGAs. In the basic configuration the ASIC can handle input ranges from ±0.25 V to ±2 V differentially, or 0.5V to 3.3V pseudo-differentially. Fine-tuning of gain and offset is performed digitally, and digitized sensor data is transmitted on nine 480-Mbps high-speed serial LVDS channels. The ASIC includes a digital interface (DIN/DOUT) for controlling the ROIC, as well as analog reference voltages (AOUT) for biasing the sensor. Programming NIRCA MkII is possible via an SPI interface. Once a program has been loaded into the internal ECC RAM, the sequencer can execute a variety of tasks, including ADC sampling control, configuration, waveform generation, and control of both analog and digital modules. NIRCA MkII uses the design against radiation effects (DARE), making it suitable for use in both space and terrestrial applications at ambient temperatures ranging between -40°C and +85°C [RD03].

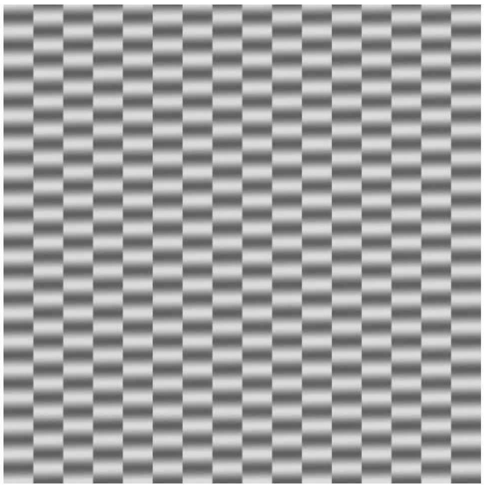


Board-Level Electronics with NIRCA MkII

The figure illustrates the board-level electronics (left) and a test image acquired with all 16-analog inputs (right). The setup only illustrates how an FPA can be connected via a flex-cable – the test image did not use any FPA. We acquired the test image using a 3.112-kHz sine wave of 2.2-V_{pp} and 800-mV offset connected to 8 odd-number video inputs and the inverted sine wave connected to the other 8 even-number inputs. For this measurement we grounded the negative differential input and only applied signal to the positive differential input. The video data was transmitted to a computer via two cables using 2 Camera Links (not shown). We used a suitable frame grabber located in the computer.

The result is an image that contains 1024 samples in y-direction and 16-bands in the x-direction (corresponding to the 16 video inputs). Each band has 1024 x 64 samples, giving a total array of 1024 x 1024 samples in the image. At the 12-Msps sampling rate the frames are acquired at 732fps. The total sustained data rate via the 2 Camera Links is about 3Gbps. The board-level electronics has connectors that allow one to connect to a FPA located inside a separate enclosure, possibly cooled and with optics.





Acknowledgements

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References

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[RD02] A. Hasanbegovic, et al., IR FPA Readout System with the NIRCA MkII ASIC, Space & Scientific CIS Workshop, November 26-27, 2024 in Toulouse

[RD03] IMEC, DARE – radiation hardening by design, https://dare.imec-int.com/en/home