Development of an Infrared FPA Readout System with the NIRCA ASIC

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Abstract

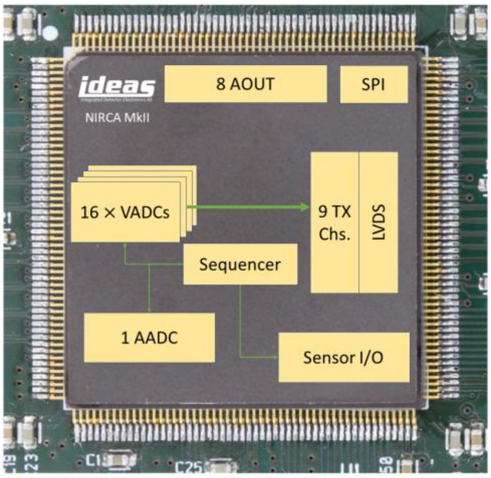
This paper describes the development of a focal plane array (FPA) readout system based on the NIRCA application specific integrated circuit (ASIC). The system aims to reduce the size, weight, power, and cost of IR image sensor systems. We have developed NIRCA and board-level electronics with NIRCA that 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 packaged in 208-pin CQFP, which currently is being qualified for flight. We describe the functionality and performance of NIRCA with the board-level electronic system. Using a function generator connected to all 16 video inputs we demonstrate that the system can read out with 16-bit resolution and transmit mega-pixel frame size at a frame rate of up to 183fps (frames per second).

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.

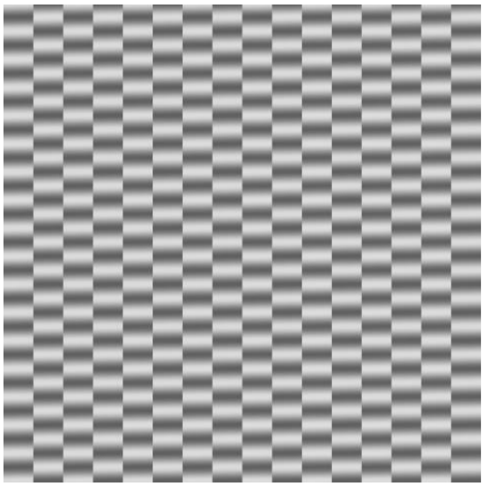
NIRCA

The Near Infrared Readout Controller ASIC (NIRCA) 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 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 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 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 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 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

The figure illustrates the board-level electronics (left) and a test image acquired with all 16 analog inputs (right). The setup illustrates how an FPA can be connected via a flex-cable. Other solutions are possible, too, and are up to the users. The board-level electronics has standard double-row pin headers that allow one to connect to a FPA located in a separate enclosure, possibly cooled and with optics. The test image shown here 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 from a function generator. The signal was connected to 8 odd-number video inputs and the inverted signal was 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 the frame gabber Radient eV-CL by Zebra Technologies Corp.
The test image has 1024 sample values (pixels) in y-direction and 1024 pixels in x-direction. One can see 16 vertical bands that correspond to the 16 video inputs. Each band has 1024 x 64 pixels, and each pixel value has 16-bit. Hence, the test image has a frame data size of 1024 x 1024 x 16 bit. The data rate is 3.072Gbps, given by 16ADC x 16bit/ADC x 12Msps. Hence, the test image acquisition demonstrates 183-fps frame rate with 16-bit mega-pixel resolution.



Acknowledgements

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References

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