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A Family of High Performance TDI Image Sensors

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ABSTRACT

A family of CCD image sensors has been designed to offer bi-directional, stage-selectable sensors with vertical anti-blooming, combined with high speed, multi-tap outputs for use in time delay integration (TDI) operation. This family of sensors offers performance characteristics that represent a significant step forward in TDI technology.

The CCD architecture is illustrated in Figure 1. The 2048H x 144V member of the family has a 26.6mm x 1.9mm active image area, while the 4096H x 96V member of the family has a 53.2mm x 1.2mm active image area - both have 13μm square imaging pixels. The stage selection, vertical anti-blooming (VAB)[1] and high performance output stage are the main technical features with this image sensor design. The sensors operate at output data rates of 25 MHz from 8 parallel taps, for a combined data rate of 200 MPixels/second. A digital camera, the DALSA CT-F3, has been designed around the sensor, which was used to demonstrate its performance.

The combination of vertical anti-blooming and stage selection allows the fabrication of a bi-directional sensor with programmable responsivity. This allows the user of a TDI sensor based inspection system to change the system sensitivity in real time to adapt to different illumination levels. The use of a negatively biased stage selection gate in a sensor without VAB requires the use of a separate drain to remove excess charge collected by the inactive TDI stages. With this design, the VAB structure and stage selection gate have been designed so that the excess charge is directly removed to the substrate. The sensors are packaged in a novel ceramic PGA package design, using a ceramic slug for improved thermal and flatness characteristics. The sensor design includes output tapers[2] to allow for a high performance readout structure in a tapped architecture. This proprietary architecture permits the use of isolation pixels in the readout register and an optimized output amplifier design for maximum performance. The use of VAB in TDI sensors[3] is a new concept which provides a significant advance in the utility of this technology.

The paper will present detailed characterisation data for the sensor, its antiblooming and stage selection performance, with a discussion of the measurement methodologies employed.

References

[1] Anti-Blooming Optimisation using Simulations and Measurements for a VAB process. IEEE '97 Workshop on CCD & Advanced Image Sensors, P14-1, Gareth P. Weale; Martin J. Kiik; Eric Fox; S. Gareth Ingram

[2] Frame Transfer Area Array Sensor with Vertical Antiblooming and Novel Readout for Enhanced Performance, IEDM 97 8.2.1, Martin J. Kiik; Colin Flood; Gareth P. Weale; S. Gareth Ingram

[3] A Time Delay and Integration Image Sensor with High Speed Output Architecture, SPIE 97, 3301-02, Gareth P. Weale, Colin J. Flood and Douglas R. Dykaar

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Figure 1: 2K Sensor Architecture

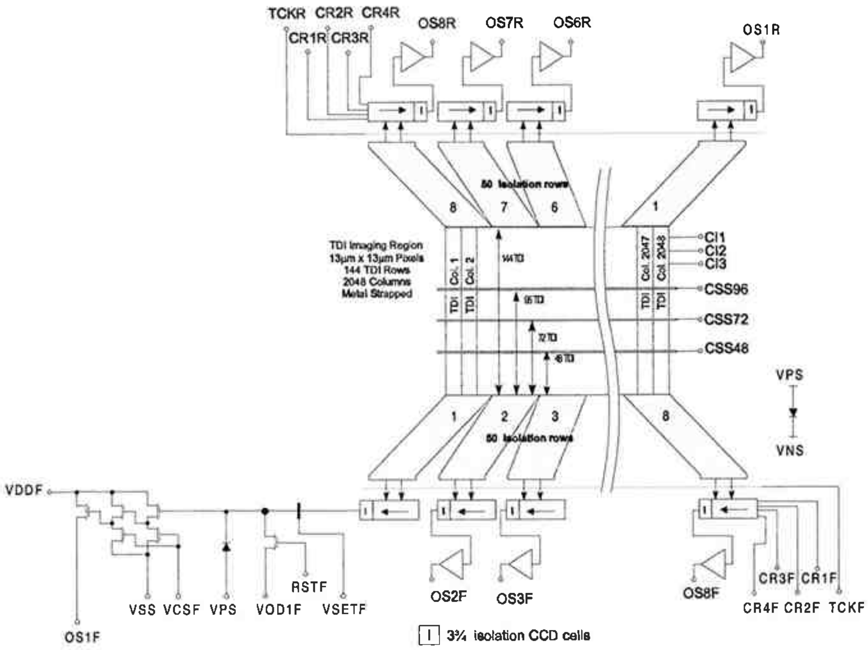

Table 1: CCD Sensor Performance

Parameter	**Test Results**	**units**
Output Swing (Vsat)	**1000 ± 160**	**mV**
Responsivity:(96 stages) peak λ=600 nm λ=450 nm	 **440 ± 30** **405** **225**	**V/µJ/cm²**
Vertical Antiblooming	**>>100x** **>13x per stage (2k)** **>25x per stage (4k)**	
VCTE	**2.6 ± 0.5**	**%OS def.**
HCTE	**<1%**	**%OS def.**
CCE	**5.2 ± 0.3**	**µV/e**
RMS Noise (calc. kTC)	**0.31**	**mV**
Dynamic Range	**3050:1 (25°C, 3.5 kHz)** **2300:1 (70°C, 40 kHz)** **930:1 (70°C, 3.5 kHz)**	
Linearity	**±1% Vsat typical**	
PRNU (incl. 1st pixel)	**3.2 ± 1.2**	**%OS p-p**
PRNU (pixel-to-pixel)	***not measured***	**%OS p-p**
FPN (incl. 1st pixel)	**8 ± 2 mV p-p (3.5 kHz),** **limited by random noise**	**mV p-p**
CH-CH Mismatch	**<5%**	
Amplifier Output Impedance	**150 (I_{LOAD}=7 mA)**	**Ω**
Stage Selection (non)Linearity	**<2%**	
Amplifier Slew Rate	**~100 V/µs**	**V/µs**