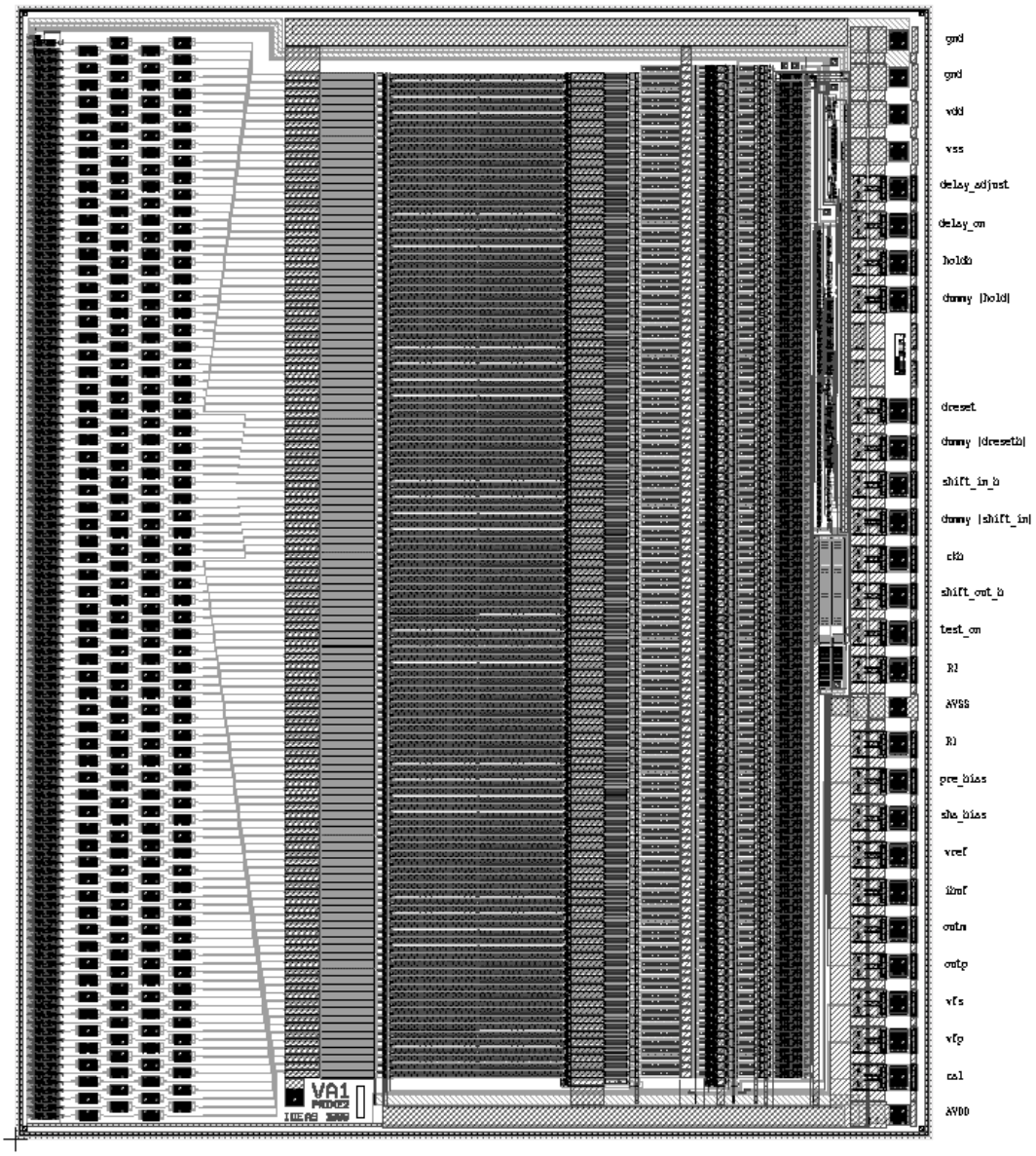
VA1_prime2

preliminary version



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1. General

- Description:

  This documentation covers both versions of the chip, namely the *Va1_prime2* and the *Va1_prime2.2*. Both are128 channel low-noise/low power charge sensitive preamplifier-shaper circuits, with simultaneous sample and hold, multiplexed analogue readout and calibration facilities. The difference of the chips is the current compensation scheme used.

2. Physical

- Process: 0.35 µm N-well CMOS, double-poly, triple metal.
- Die size: 4.95 mm x 6.12 mm, thickness: ~ 725 µm
- Input bonding pads:

Four rows. Normal connection to rows 1 and 2, redundant pads in rows 3 and 4.

Pad size: 50 µm x 90 µm
Pad pitch: 91.2 µm
Row pitch: 170 µm (see. fig. 3&4)

- Output, control and power pads:

Single row.
Pad size: 90 µm x 90 µm
Pad pitch: 200 µm (see fig. 3)

3. Electrical

All values are preliminary, and based on simulations. Verification with measurements has to be conducted.

Power rails: Vdd = +1.5V, Vss = -2.0V

Each with separate connections for analogue (avdd and avss) and digital sections (dvdd, dvss) of the chip.

Back contact: metalized, connect to avss (-2 V)

Current draw: Quiescent:

dvdd:	< 10	µA
dvss:	< 10	µA
avdd:	30	mA
avss:	- 95	mA
gnd:	65	mA

Input bias currents: Nominal values
(all driven to devices (e.g. resistors) referred to avdd)

pre_bias:	500µA
sha_bias:	22µA
ibuf:	140 µA

(ibuf only during readout)

Peaking time:

Nominal:	~0.6 µs
Adjustable:	~ 0.3µs - 1µs

Power dissipation: Typical values
Quiescent: 235 mW

ESD Protection:	Inputs:	None
	Control and other I/O :	Protection diodes to Vdd and Vss. ~300Ω series resistor except for *cal*, *outm* and *outp*.

Input stage: Input device: PMOS referenced to gnd

Signal input potential: ~ -1.2 V to -1.3 V

Gain: The differential current gain on the outputs *outp* and *outm* is about ±10 µA/fC (at 1 Mip). The gain depends on setting parameters like VFS, Sha_bias etc.

Linear range: About ± 10 MIP (can handle both signal polarities)
20 MIP in single polarity can be used with adjustment of VREF

Noise (ENC): Typical values (to be measured):

180 + 7.5/pF e^-rms for 1 µsec peaking time

Readout: Controlled via 128-bit (output) shift register.

Analogue outputs (outp, outm) of two or more chips can be connected in parallel to drive the inputs of an external, differential, transimpedance amplifier.
Max. read-out is 10 MHz, here care has to be taken not to load the output buffer with to high capacitance and resistance.

Calibration/test: Voltage step applied via external 1.8 pF capacitor to the cal-input. 2 mV step represents 1 MIP (=22400 e^- or 3.6 fC).
Some additional noise has to be taken into account in test mode due to serial resistance and additional capacitance.
Calibration signal can be given to one channel in a given chip at a time. The channel is selected via a 128-bit (input) shift register.

4. Pad Description

The output, control and power pads of the *Va1_prime2* are listed below from top to bottom. (see chip plot on next page (Fig. 1.).

Pad name	Type	Description	Nominal value
gnd	p	signal ground	0 V
vdd	p	digital vdd	+1.5 V
vss	p	digital vss	-2.0 V
delay_adjust	ai	not in use	connect to gnd
delay_on	di	not in use	connect to dvss
holdb	di	used to hold analogue data, see fig. 3.	Logical
dummy (hold)	di	*)	Logical
dreset	di	reset of digital part	Logical
dummy (dresetb)	di	*)	Logical
shift_in_b	di	start pulse for read-out	Logical
dummy (ck)	di	*)	Logical
ckb	di	clock for read-out register, see fig. 3.	Logical
shift_out_b	do	Signalling end of read-out. Can be used as shift_in_b for next chip.	Logical
test_on	di	Turns chip into test-mode	Logical
R2	di	control of CC-resistor value	Logical
avss	p	Analogue vss (+ chip backplane)	-2.0 V
R1	di	control of CC-resistor value	Logical
pre_bias	ai	Bias current for pre-amplifiers.	500 µA
sha_bias	ai	Bias current for shaper-amplifiers.	22 µA
vref	ai	not in use. (recommended connected to decoupling capacitor).	
ibuf	ai	Bias-current for output-buffer.	140 µA
outm	ao	Negative output signal (current)	
outp	ao	Positive output signal (current)	
vfs	ai	Control voltage to feedback resistance in shaper-amplifier	700 mV
vfp	ai	Control voltage to feedback resistance in pre-amplifier	-0.2 V
cal	ai	Test input signal	1 MIP
avdd	p	Analogue vdd	+1.5 V

p = power, di = digital in, do = digital out, ai = analogue in, ao = analogue out

*) These 'dummy' signals are recommended for high performance. They should be used to add complementary signals to the effective ones in order to minimise digital signal-feedthrough to the analogue output.

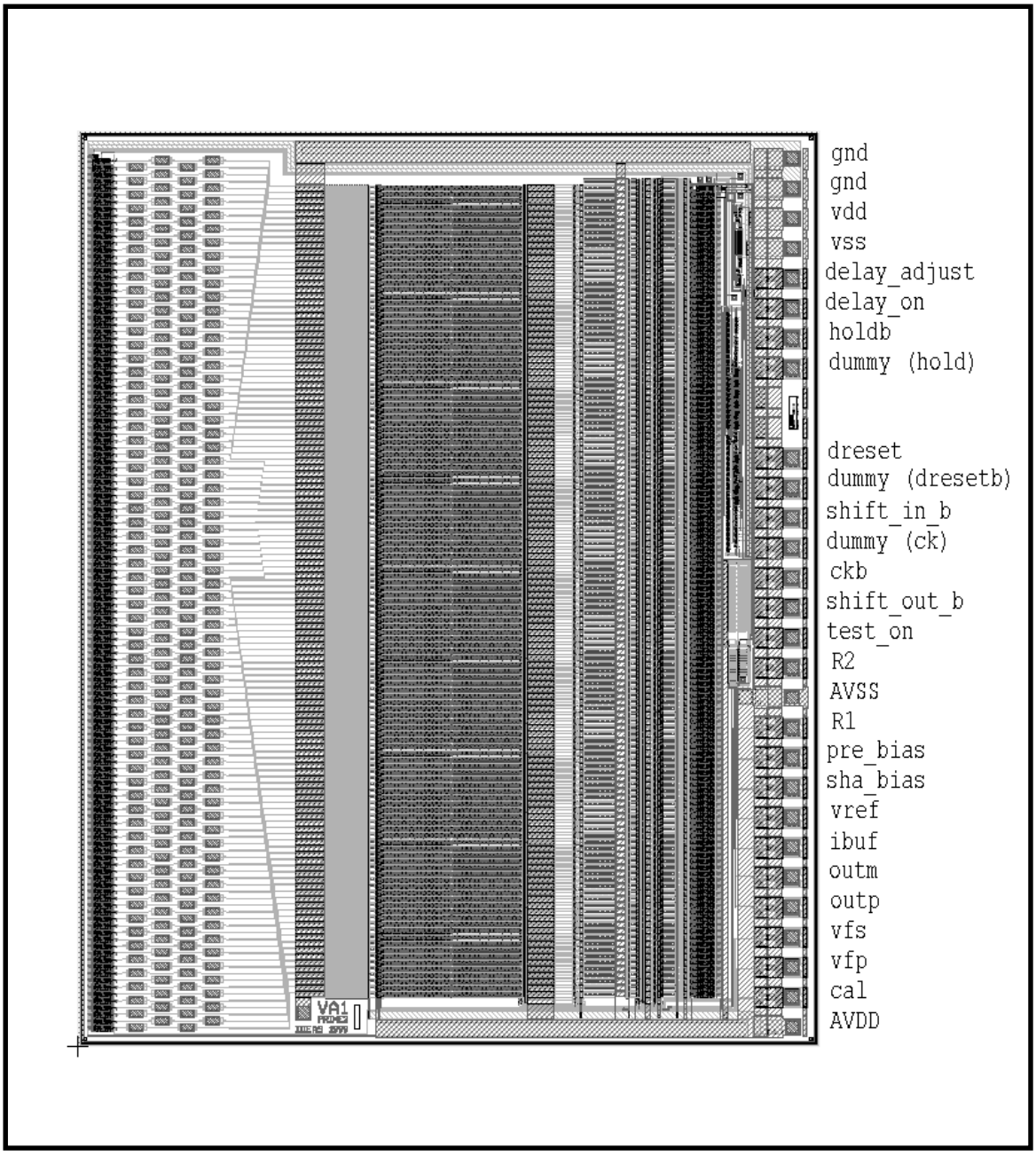

Fig. 1: The *VA1_prime2* circuit.

The output, control and power pads of the *Va1_prime2_2* are listed below from top to bottom. (see chip plot on next page (Fig. 2.).

Pad name	Type	Description	Nominal value
gnd	p	signal ground	0 V
vdd	p	digital vdd	+1.5 V
dvss	p	digital vss	-2.0 V
delay_adjust	ai	not in use	connect to gnd
delay_on	di	not in use	connect to dvss
holdb	di	used to hold analogue data, see fig. 3.	Logical
dummy (hold)	di	*)	Logical
nside	di	Control of the polarity of the cc	Logical
cc_on	di	Enabling of the cc	Logical
dreset	di	reset of digital part	Logical
dummy (dresetb)	di	*)	Logical
shift_in_b	di	start pulse for read-out	Logical
dummy (ck)	di	*)	Logical
ckb	di	clock for read-out register, see fig. 3.	Logical
shift_out_b	do	Signalling end of read-out. Can be used as shift_in_b for next chip.	Logical
test_on	di	Turns chip into test-mode	Logical
cc_bias	ai	Bias correction for current comp. Internally generated.	0 µA
avss	p	Analogue vss (+ chip backplane)	-2.0 V
avss_cc	p	vss for the cc-transistor	-2.0 V
pre_bias	ai	Bias current for pre-amplifiers.	500 µA
sha_bias	ai	Bias current for shaper-amplifiers.	22 µA
vref	ai	not in use. (recommended connected to decoupling capacitor).	
ibuf	ai	Bias-current for output-buffer.	140 µA
outm	ao	Negative output signal (current)	
outp	ao	Positive output signal (current)	
vfs	ai	Control voltage to feedback resistance in shaper-amplifier	700 mV
vfp	ai	Control voltage to feedback resistance in pre-amplifier	-0.2 V
cal	ai	Test input signal	1 MIP
avdd	p	Analogue vdd	+1.5 V

p = power, di = digital in, do = digital out, ai = analogue in, ao = analogue out

*) These 'dummy' signals are recommended for high performance. They should be used to add complementary signals to the effective ones in order to minimise digital signal-feedthrough to the analogue output.

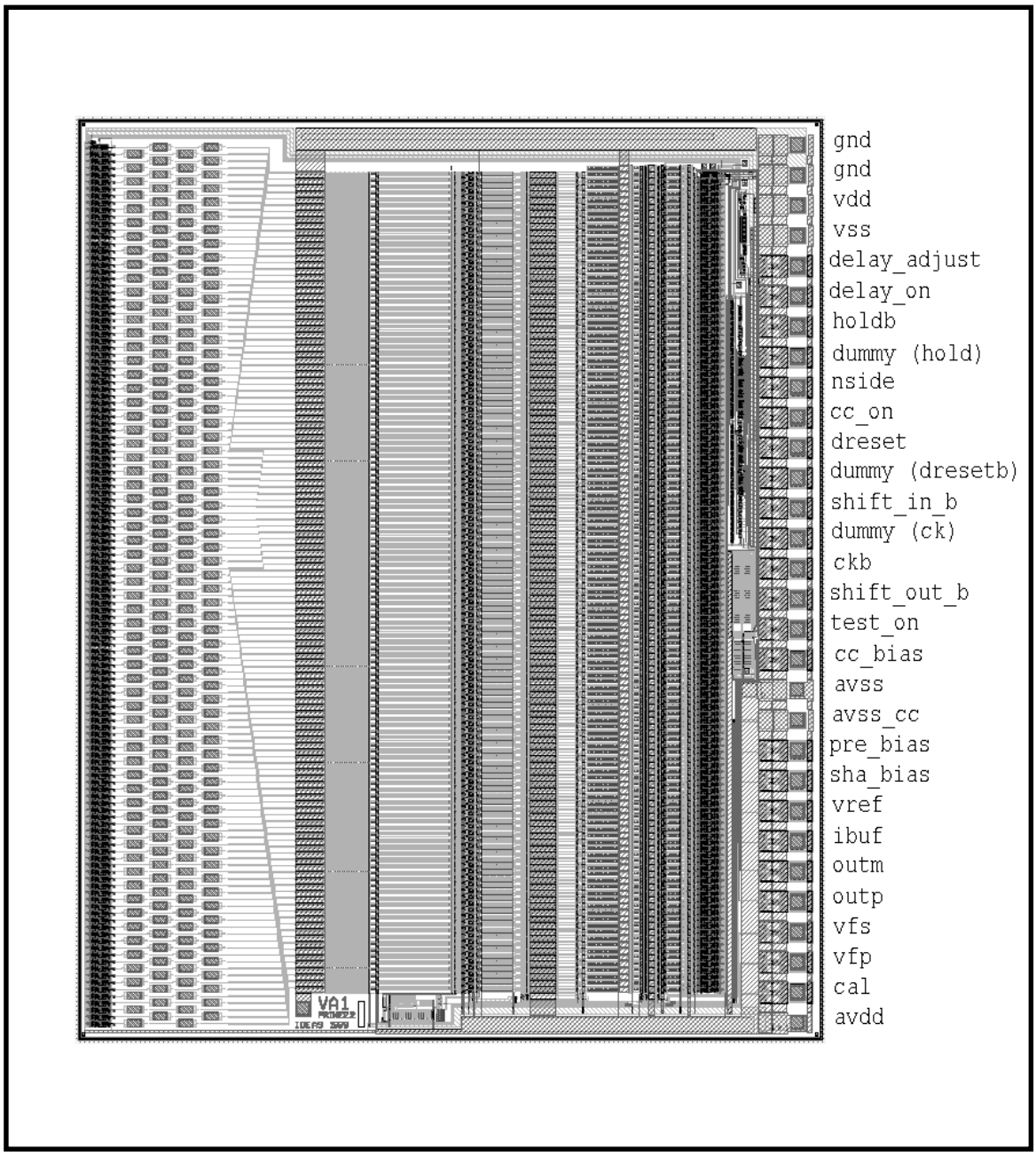

Fig. 2: The *VA1_prime2_2* circuit.

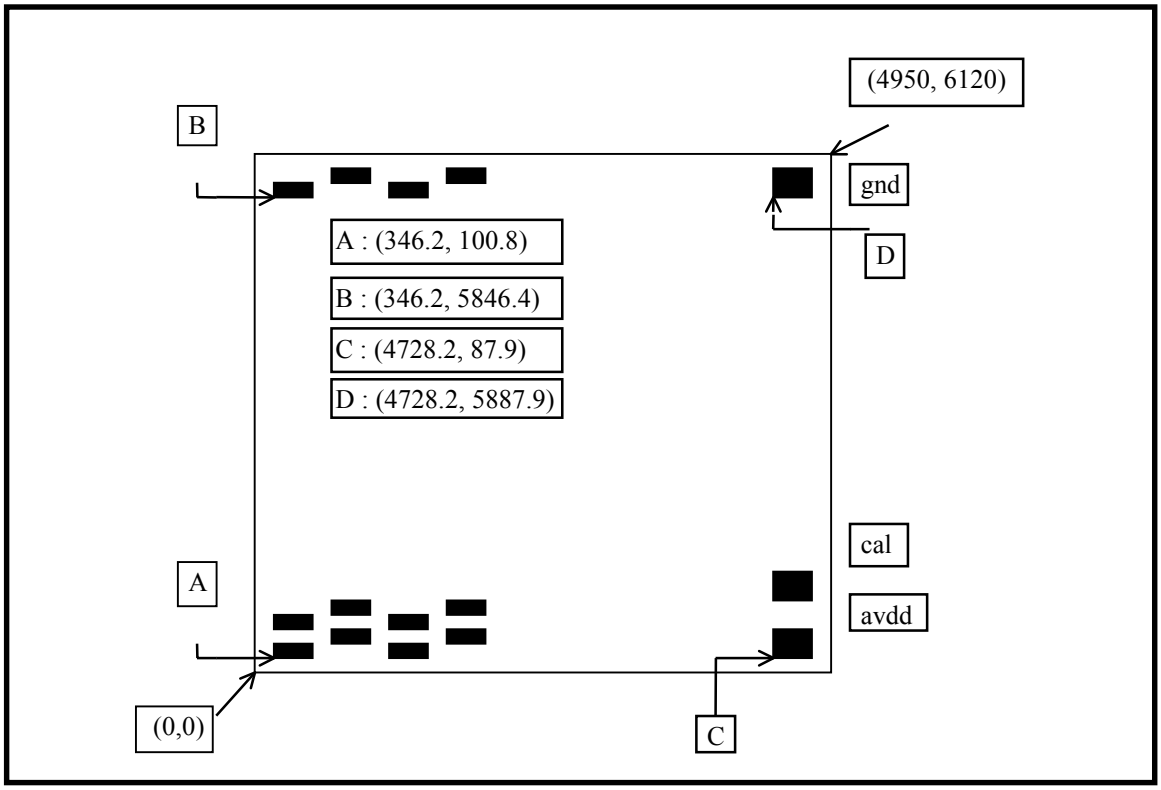

Fig. 3 Chip geometry & pad placement (Not to scale - all dimensions in µm. Please note that the referred co-ordinates are layout co-ordinates. Add 50-100 µm on each side for scribe/cutting tolerances).

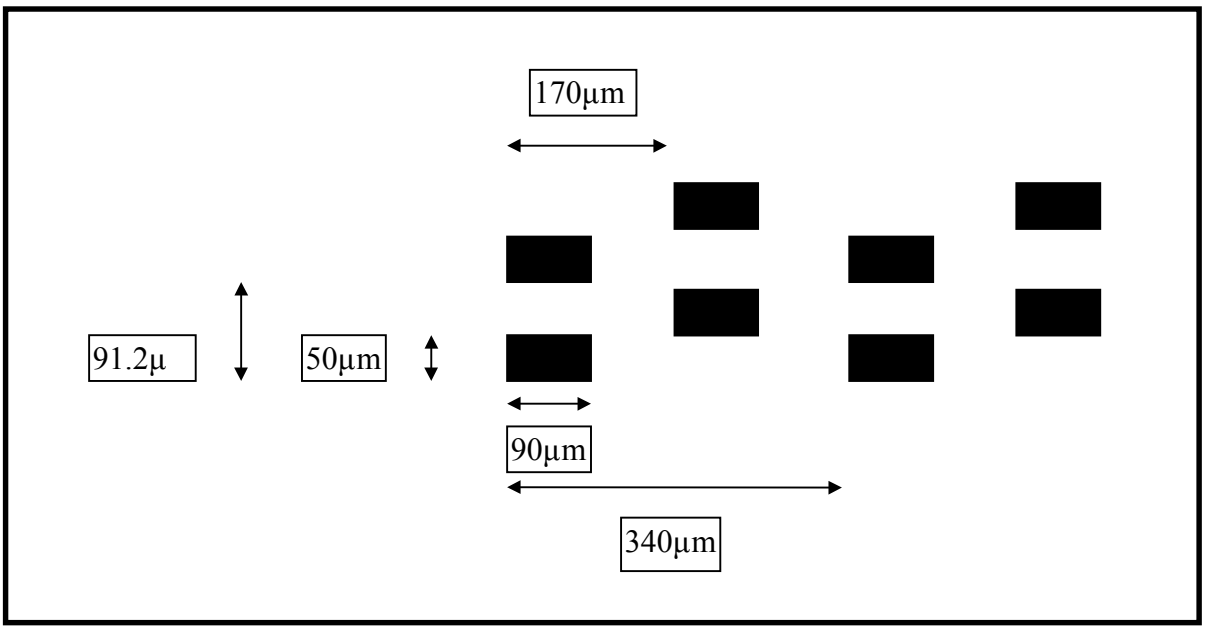

Fig. 4. Definition of input pad size and pitch.

5. Functional Description

As shown in Fig. 4 the chip consists of 128 identical parallel charge sensitive amplifiers.
The output of all amplifiers enters corresponding inputs of a 128 channel multiplexer. The switches in the multiplexer are controlled by a bit-register which runs in parallel. The output of the mux. goes directly out of the chip via the output buffer (signal = '**outp**' - '**outm**'). Only one of the switches in the mux can be ¨on ¨ at a time. That is one amplifier (channel) at a time can be seen on the output of the chip. The bit in the register ripples in sequence from the top- to the bottom- channel by clocking '**ckb**'. The clock can be stopped at any point which will leave the connection between the current channel and the output, which remains enabled.

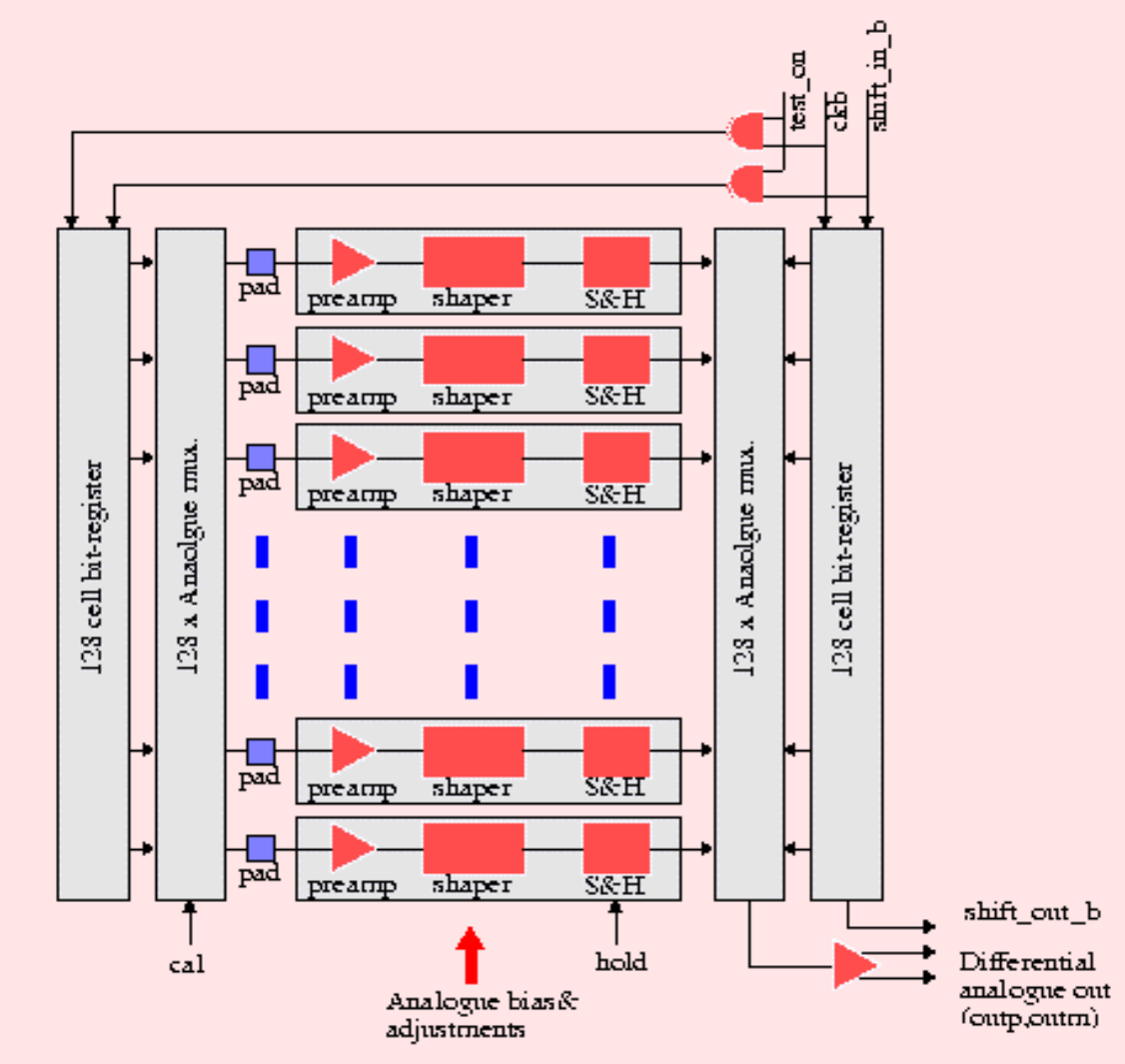

Fig 5. VA1_prime2 Architecture.

The only difference between the chips, the detector leakage current compensation schemes, also explains the difference in the pad assignment. In the *Va1_prime2*, current compensation is achieved by placing a Nwell-resistor in parallel with the *Vfp*-transistor in the preamp feedback-loop. The two control signals *R1* and *R2* are used to choose the value of the Nwell-resistor (see table 1). The actual current sinking is done by the preamp. A sketch showing the principle is shown in figure 6.

Va1_prime2_2 uses an active current compensation by introducing a MOS source/sink at the preamplifier's input. The MOS device is controlled by a slow differential amplifier, which senses the voltage difference between the input and the output nodes of the preamp. The control signal *nside* can be used to set the current compensation to *source*- or *sink*-modus depending on which side of the detector the leakage current originates. Figure 7 shows the concept of this scheme.

R1	R2	Nwell resistor value
0	0	Shut off
1	0	1.5 MΩ
0	1	3 MΩ

Table 1: Nwell resistor value as a function of the control signals *R1* and *R2*.

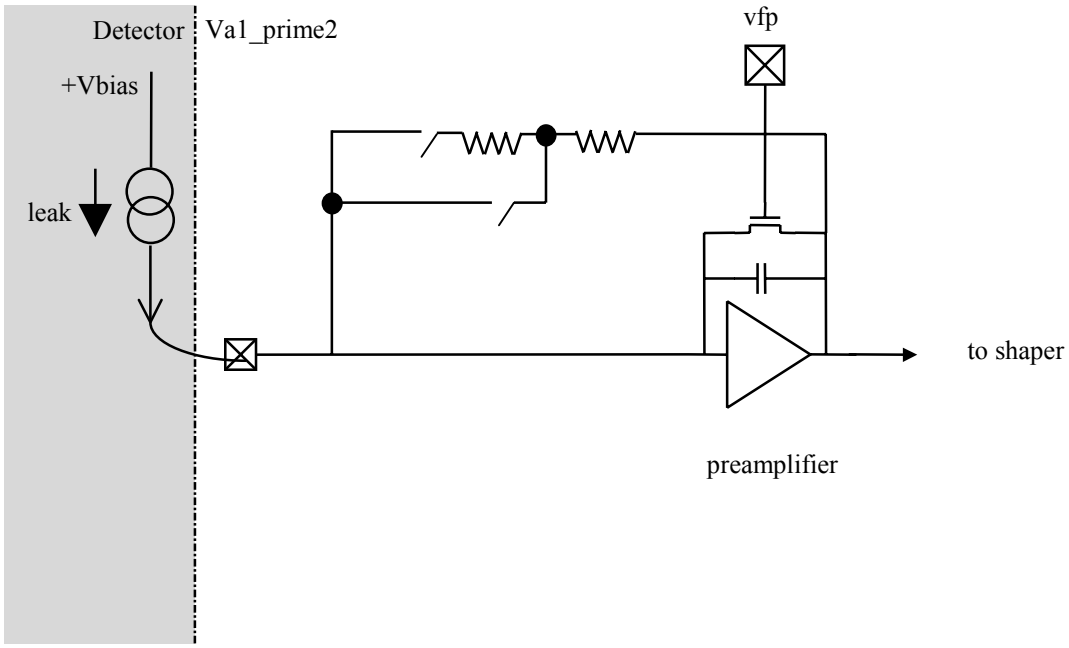

Fig. 6: Simplified schematic showing the current compensation employed in the *Va1_prime2*. The switches are operated by *R1* and *R2*.

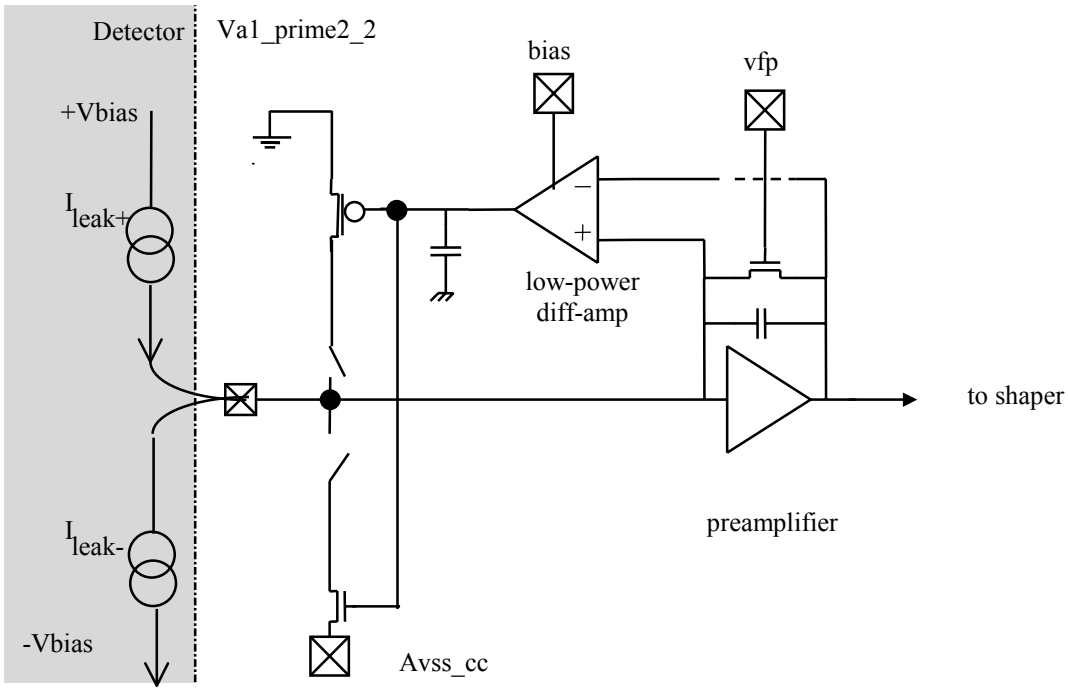

Fig. 7: Simplified schematic showing the principle of the current compensation used in the *Va1_prime2_2*. The switches are controlled by *nside*.

6. Normal mode of operation

The normal mode of operation is that the 128 inputs are connected to a detector from where the charge signal comes. After the physics event, each channel will integrate its eventual signal for 1µs. Usually, after the peak is reached (1µs), an external '**holdb**' signal should be applied to sample the value. Immediately after this a sequential read-out can be performed by activating the output bit-register using '**shift_in_b**' and '**ckb**'. See fig. 8 for an example of the timing in this mode. The logic part of the chip can be reset either by applying the '**dreset**' or, simply by running through a normal read-out once.

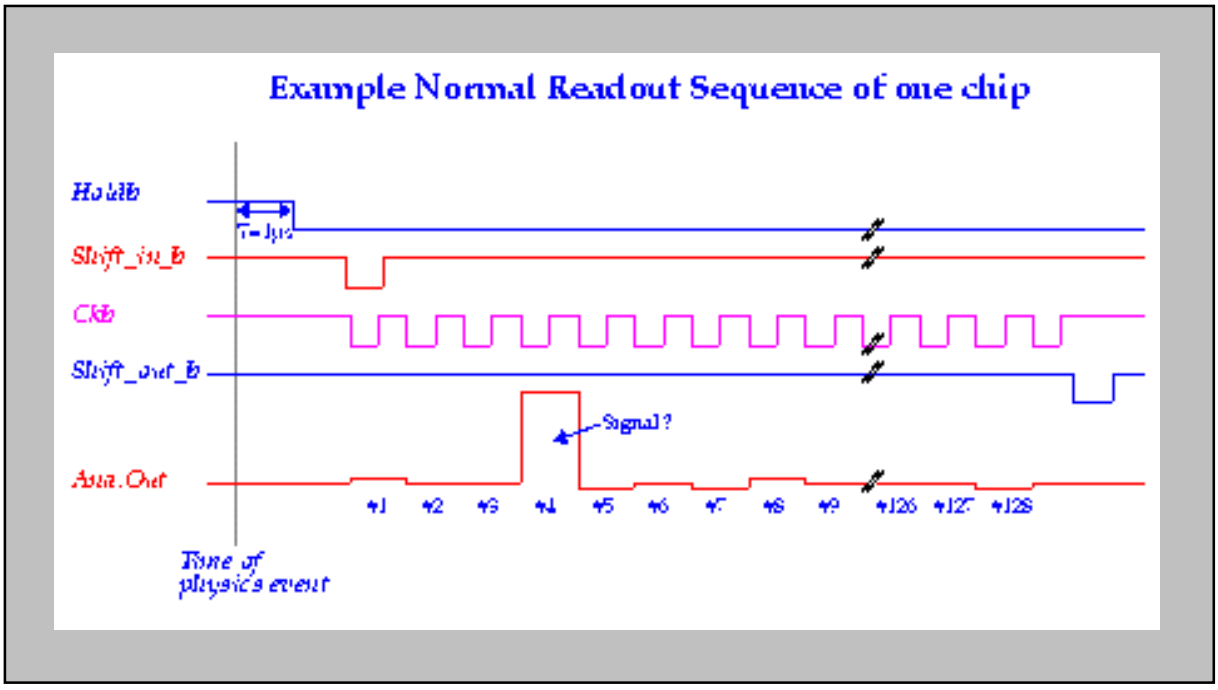

Fig 8. Read-out timing of VA1_prime2.

7. Operation in test mode

Each of the inputs of the amplifiers can be accessed via the input pads on the left side, see Fig. 5. In test mode, it is not necessary to connect any of these. Instead, the test facility of the chip can be turned on ('**test-on**'). This will enable another mux./bit-register on the input to run exactly in parallel with the output mux./bit-register. This input mux. connects all the inputs to the '**cal**' pad via a switch controlled by the bit-register. Also, in this case, only one connection at a time is possible and this connection will always correspond to the same channel as is connected in the output mux.

8. Bias current generation

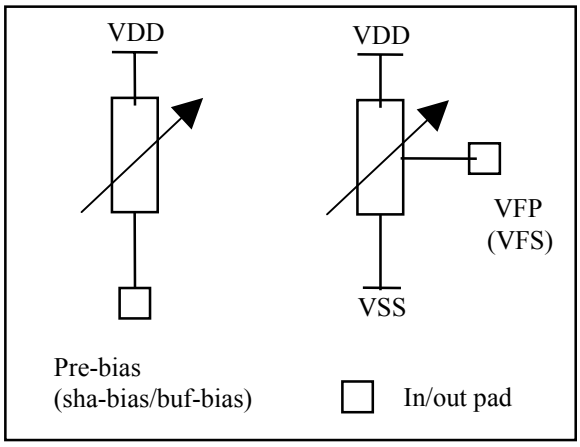

Fig 8. Bias current & Voltage generation

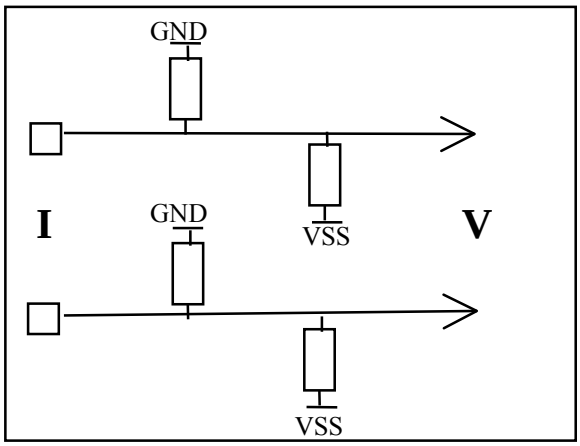

Fig. 9. Analogue-Out termination (1 kOhm recommended)

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