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To: XIS Team
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Subject: Charge injection failure modes

Summary

At our meeting at MIT on June 28, we agreed to review and summarize the effects of various failure modes associated with charge injection. To do this, we considered the results of open circuits and various shorts in the charge injection signals. Results are summarized here. The main conclusion is that a short of the charge injection input diode bias to ground (or to any potential below about +2 volts) would saturate the detector for the duration of the short. While such a short would be catastrophic, it must be recognized that shorting to ground of many existing CCD signals (e.g., video outputs, reset diode) would also be catastrophic.

Since the most serious failure mode is ID shorted to ground, (which results in detector saturation), we may want to consider configuring the electronics so that the input diode bias ID > $V_{chan,min}$ always, where $V_{chan,min} \sim +3$ V is the minimum value of the channel potential.

Nomenclature

The proposed charge injection structure is described in a memo by G. Prigozhin [1] . Table 1 defines abbreviations and normal potentials for the signals involved in charge injection.

Table 1: Charge injection signal names and typical operating levels

Signal	Abbreviation	Operating Levels (V)	
		Integration	Injection
Input Diode	ID	+7	+7
Input Gate	IG	-3	+7/-3 (clocked)
Image Area Phase 1	IA1	+2 or +10	+5/-5 (clocked)

[1] `ftp://space.mit.edu/pub/xis/memos/cistructure_gyp.ps`

Failure Effects

The effects of various failures associated with these signals are listed in Table 2.

Table 2: Effects of shorts and opens in charge injection signals

Signal	Failure	Consequences
ID	short to gnd	Complete saturation; detector useless during short. See note 1.
ID	open	Some injection of leakage current in some rows. See note 2.
ID	short to IG	Loss of injection capability. If IG < IA1 high, detector saturated.
IG	open	Loss of injection capability. Detector ok provided ID > IA1(high)+5V is possible. Otherwise detector saturated.
IG	short to gnd	Loss of injection capability. Detector ok. See note 3.
IG	short to IA1	Loss of injection capability. Detector ok provided ID > IA1(high)+5V is possible, otherwise detector saturated. See note 3.

Explanatory Notes

1. *ID shorted to ground.* The potential in the buried channel under the gates is always positive, no matter what is the voltage applied to the gates. This is so because the channel stops ensure that the surface potential is always non-negative and the buried channel potential is always above that of the surface. As a result, if the input diode is grounded, it will becomes a source of electrons that will flow into the array. The input diode, CCD gates and reset drain comprise the source, gates and drain, respectively, of an MOS transistor. This transistor cannot be turned off because it has a buried channel.

   The minimum value of the channel potential, $V_{chan,min} \sim +3$ V occurs when the (silicon/insulator) surface is inverted. It may be wise to configure the bias supply for ID so that ID $> V_{chan,min} \sim +3$ V always.

2. *ID open.* In this case the ID will become reverse biased due to sweeping away of charge exceeding level of channel potential under the adjacent gates. The ID will collect some amount of dark current, most of it during the integration. Some of this charge may spill into the top row of the CCD. When the image-array clocking starts, the applied potential propagates along the polysilicon from the edges to the middle of the device. In constrast, the input diodes in all columns are connected by highly conductive aluminum bus and thus are all at the same potential. As a result, columns at the edges of the device are likely to get some extra charge injected from the diodes until the potential on the diode becomes higher and the injection stops. The top few rows of the outside columns of the device may therefore show excess dark current. The level of this parasitic injection will depend entirely on the level of the diode leakage current. This current might be very small at -90 C.

3. *IG shorted to ground or IA1.* In these cases injection could in principle be achieved by clocking the ID potential.