

## **SMEAR EFFECT IN HIGH SPEED SHUTTER CAMERA**

The latest development in industrial CCD cameras is high speed electronic shuttering to freeze moving objects. The high-speed shutter is achieved by using a vertical-overflow drain type interline transfer CCD.

First, the interline transfer CCD accumulates or integrates the photo-charges in each photo diode and transfers the charges simultaneously to vertical registers (CCD vertical shift register). In this structure, all pixels are exposed at exactly the same time.

Second, for short integration (shuttering), unnecessary charges must be dumped out prior to integration. In order to provide fast shuttering, the discharge process (dump out) must be done faster than the shutter speed required.

The vertical overflow drain structure dumps out the charges to the substrate all together in less than a few  $\mu\text{sec}$ , whereas conventional lateral overflow structure MOS or frame transfer devices take significantly longer to discharge. This limits the maximum shutter speed to 1/2000 sec. at best. The vertical overflow drain structure provides the shutter speeds faster than 1/30,000 sec.

### **Smear effect**

As a natural CCD characteristic, CCD shift registers are light sensitive. When strong light hits a CCD while the shift registers are active, the light signal is output as a vertical smear.

The amount of the smear is proportional to the light intensity, and it is also relative to the light's spectral characteristics. However, the smearing stays the same regardless of the shutter speed.

For example, if the smear is 1/1000 of normal video level at normal speed, the level is  $700 \text{ mV}/1000 = 0.7 \text{ mV}$  at 16.7 msec of integration (1 field integration). However, if the same smear is seen at 1/10,000 sec. of shutter (100  $\mu\text{sec}$  of integration), the video signal is reduced to  $700 \times 0.1 \times 1/16.7 = 4.19 \text{ mV}$  and the ratio between 0.7 mV of smear is only 6:1. Therefore, the smear becomes significantly visible. Unfortunately, this is the nature of CCD's and customers must accept this fact.

### **Reducing the smear**

Much effort to reduce the smear has been done by the CCD manufacturers. Since the light leak into the shift registers is the main cause, improving the light shield process and adding built-in micro lenses are two key improvements.

PULNiX uses CCDs with microlenses for most standard CCD cameras, and new TM-9700 and TM-1000 series will be provided with microlens options.