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Dead Pixels

Misbehaving Pixels Explained

“Misbehaving pixels” refers to pixels or photosites that do not respond as expected. This includes but isn’t limited to stuck, hot, dead, lit, warm, defective, or flickering pixels. These may appear as isolated pixels or clusters, sometimes persistent across frames, or randomly changing on a per-frame basis.

All CMOS sensors inherently contain thousands of such defective pixels—an unavoidable result of manufacturing. For perspective, a 4K UHD CMOS sensor has about 8.3 million photosites. It’s unrealistic to expect zero defects at this scale.

Why Don’t We See These Defects in Every Frame?

Sensor manufacturers test each chip with complex algorithms to map out defective pixels (see Image 1). This unique “pixel map” acts like a fingerprint for each sensor (see Image 2).

Pixel Correction

During sensor readout, these maps are used to replace defective pixel values with estimated values calculated from neighboring pixels (see Images 3 and 4). It’s akin to the defective pixel “cheating” by borrowing information—but this correction is intentional and necessary.

Why Do Pixels Still Occasionally Appear Misbehaving?

Correction algorithms are not flawless, and pixel response varies with sensor temperature, integration time (shutter speed), exposure, and even cosmic radiation. As sensor temperature shifts, some pixels may temporarily misbehave. Sensors can also degrade over time, developing new defects after factory calibration.

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Many cameras let users perform sensor recalibration—known by names like Black Shading, Black Balance, dark frame subtraction, or Automatic Pixel Restoration—to adjust pixel correction based on current conditions.

Persistent Pixel Defects

Despite recalibration, some defective pixels might remain due to limitations in the correction algorithms and diverse manufacturer approaches. For example, some brands prefer heavier in-camera processing requiring larger hardware, while others rely more on post-production fixes to maintain compact designs.

Higher resolution sensors, like 8K with ~35 million photosites (four times that of 4K), increase the chance of encountering misbehaving pixels. Thankfully, post-production software generally includes user-friendly pixel masking tools.

How to Minimize and Fix Misbehaving Pixels

- Allow cameras to warm up to stable operating temperatures and run sensor calibration as per manufacturer instructions.
- Operate the camera within specified temperature and exposure ranges to reduce pixel anomalies.
- Follow manufacturer guidance for shooting in extreme conditions.
- Utilize pixel masking tools in post-processing software; ARR and RED provide SDKs for seamless integration.
- Avoid applying global spatial noise reduction to fix misbehaving pixels, as this decreases image detail and may miss static defective pixels.
- If issues persist after proper calibration and operation, contact the camera manufacturer for further support.