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White Paper:

HTVL Effective Specification for CCTV Cameras

The HTVL Effective specification is being embraced by major camera manufacturers and experts within the video security industry as *the* modern figure of merit for CCTV camera resolution.

In the opinion of Frost and Sullivan, the proposed HTVL Effective specification is a much more relevant and accurate indication of the actual, useable resolution of CCTV cameras. In this age of digital image capture, digital recording, and display, HTVL-E provides users of security video with a more accurate benchmark to compare resolution among different video camera technologies. The standard is simple to measure on any CCTV camera using any type of image sensor, whether progressive scan or interlaced, thus Frost & Sullivan encourages its broad use within the video security industry."

Sandeep Maheshwari
Vice President of the Industrial Automation and Electronics Group
Frost & Sullivan

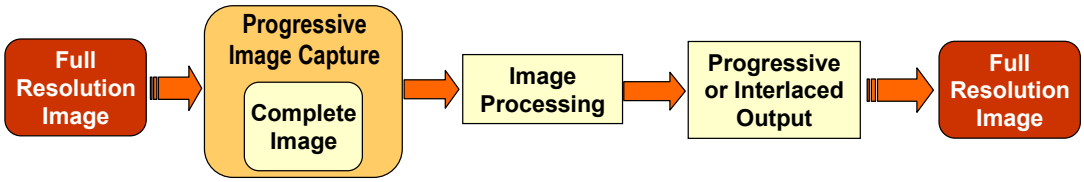
CCTV cameras capture two-dimensional images, but for decades the video security industry has only been provided with a one-dimensional specification for horizontal resolution. There are historical reasons for this based upon how the original tube-based cameras worked, but the practice of specifying HTVL has not changed primarily because analog CCD image sensors are inherently limited in terms of their effective vertical resolution, and that handicaps their overall effective resolution.

The video security industry has evolved and end users now compare IP cameras based on megapixels, a two-dimensional indicator of total image resolution. A similar figure of merit for CCTV cameras is needed to enable end users to make better informed purchasing decisions than they are able to using the legacy HTVL specification, which has become a misleading number that is sometimes improperly exploited within the industry.

Vertical Resolution Limitations of Analog CCD Sensors

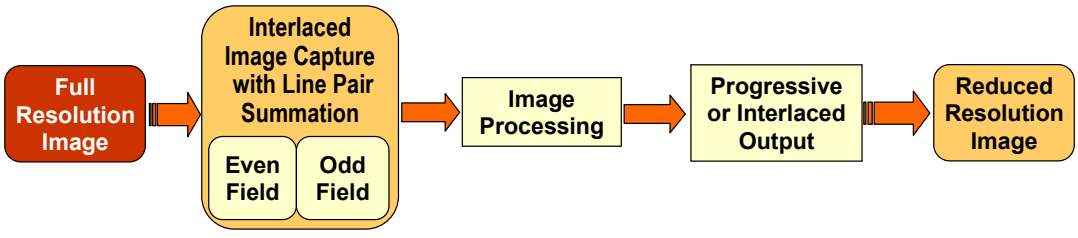
It's important to understand the inherent limitation placed on vertical resolution by an imaging solution that relies on interlaced image capture. Analog CCD sensors used in video surveillance cameras capture interlaced video using a process called line-pair summation. This improves low-light sensitivity somewhat and acts as a low pass filter, but has a side effect of decreasing the effective vertical resolution by 25%[1]. This means that a 480 line CCD sensor is limited to a maximum vertical resolution of 360 lines and that the image's total resolution is decreased by 25%. That's unfortunate for the end user because DVRs and display monitors are very capable of utilizing all 480 lines of vertical resolution. Imagers that perform progressive image capture, as is the case with Pixim's Digital Pixel System® technology, maintain the full vertical resolution.

Pixim Digital Pixel System®



Full Vertical Resolution is Maintained

Interline Transfer CCD



Vertical Resolution is Reduced by 25%
through the process of line pair summation

[1] http://broadcastengineering.com/hdtv/ccd-cmos/

The method used for capturing an image is independent from the method used to display it. CCTV cameras typically output video in an interlaced format, but that video may have been captured by the camera in either a progressive or interlaced format.

Ignore the fact that horizontal resolutions greater than 540 HTVL cannot be seen and recorded in a typical CCTV system[2], and take a look at an image produced by a new CCD sensor designed to capture a 650 HTVL image. It utilizes interlaced image capture, so it faces the same vertical resolution limitation as its 540 HTVL predecessors. This is evident in Figure 2 which shows a VTVL measurement of this sensor using the standard CCTV Labs test chart. The measured resolution is taken at the point where the four lines start to appear as three, so this camera actually measures less than the theoretical limit of 360 VTVL. Another important thing to notice is the large amount of false color noise that appears in the image starting before the 200 VTVL measurement marker. This part of the test chart is black and white, so this false color noise appears due to sampling issues that are a direct result of the sensor's vertical resolution limitation. These are real artifacts that affect the quality of the image produced by the camera.

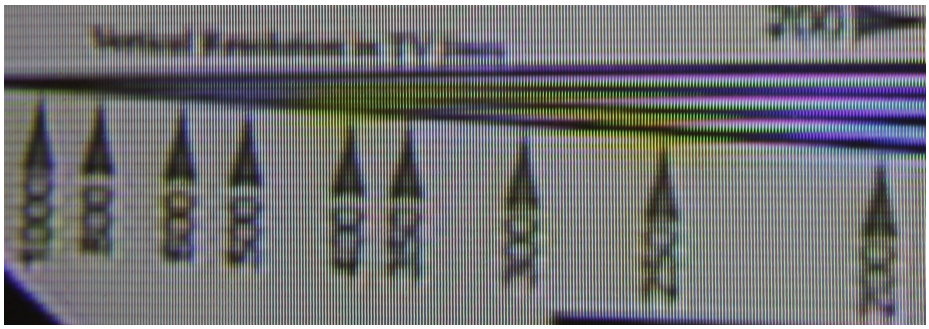


Figure 2 – Vertical resolution measurement for a 650 HTVL sensor. Note false color noise throughout wedge pattern and resolution cut off at less than 360 VTVL.

Figure 3 shows the same image from a progressive capture sensor based on Pixim's Digital Pixel System technology. Note that no false color noise appears in the image until the wedge pattern approaches the sensor's resolution limit where the lines begin to converge at 460 VTVL.

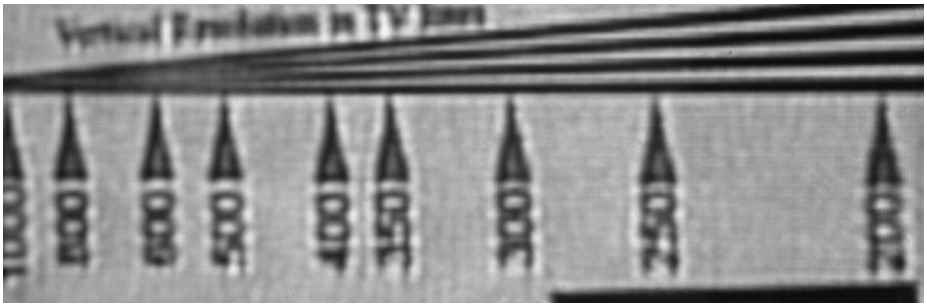


Figure 3 – Vertical resolution measurement for a progressive capture sensor without the appearance of false color noise until after the 460 VTVL limit of the sensor.

[2] http://www.pixim.com/assets/files/product_and_tech/540HTVL_Max_WP_Final.pdf

Effective Resolution

A previous paper[3] explained why horizontal camera resolution is limited to a maximum of 540 HTVL in typical CCTV systems because of inherent limitations of the composite video inputs to DVRs and LCD video monitors. That paper also showed that vertical resolutions of up to 480 VTVL are supported by those same composite video inputs. Vertical resolution is an important contributor to image quality, but it is rarely found in product literature or A&E specifications for CCTV cameras. That's not likely to change anytime soon, so it's appropriate to introduce the concept of an effective resolution specification which recognizes both horizontal and vertical components of resolution and provides them in a single number using terminology that the video security industry is already comfortable with.

The HTVL Effective, or HTVL-E specification normalizes the total image resolution to the vertical resolution of interlaced capture CCD sensors since they are by far the most common image sensor used in CCTV cameras today. Normalization simply means dividing by a constant, which reduces a large total resolution number that is difficult to remember and work with to a number that is easier to use for comparison purposes and fits within the numerical range that an end user would expect to see. The word "effective" means ready for service or action, so this specification gives a camera credit for the entire, usable image that it produces using the following formula:

$$\text{HTVL Effective} = \frac{\text{Total Resolution (H x V)}}{\text{360 VTVL}}$$

In the case of the 650 HTVL sensor that produced the image shown in Figure 2, if we give it full credit for the horizontal resolution claimed in the manufacturer's spec as well as its maximum vertical resolution of 360 VTVL, its total image resolution is 234,000 pixels (650 x 360). If we apply the HTVL Effective formula to that sensor, the math works out to an effective resolution of 650 HTVL Effective, which is exactly what they claim it to be.

$$\frac{\text{234,000 pixels}}{\text{360 VTVL}} = \text{650 HTVL Effective}$$

[3] http://www.pixim.com/assets/files/product_and_tech/540HTVL_Max_WP_Final.pdf

The progressive capture sensor that produced the image in Figure 3 has a total image resolution of 248,400 pixels (540 x 460). Using the same formula, this yields an effective resolution of 690 HTVL Effective.

$$\frac{248{,}400 \text{ pixels}}{360 \text{ VTVL}} = 690 \text{ HTVL Effective}$$

Specifying the resolution in terms of the total resolution captured by the sensor allows the end user to reach a more objective conclusion about the amount of detail they will actually be able to display and record in images produced by the camera. Image resolutions for IP cameras are already specified in a similar manner because they specify resolution in terms of the actual number of megapixels the sensor can capture. The HTVL Effective specification simply takes the same concept of total resolution and describes it using language commonly used to specify analog CCTV cameras.

Effective Resolution Is Usable Resolution

Increased vertical resolution increases a camera's effective image resolution. Higher VTVL allows CCTV cameras to capture more usable detail in an image. At the same time it prevents the camera from capturing false color noise that obscures details in images, unnecessarily bloats DVR file sizes, and confuses analytics algorithms. Standard DVRs as well as standard CRT and LCD video monitors support the additional vertical resolution. Effective resolution, as its name implies, is the best indicator for video security professionals of how effective a CCTV camera is really going to be in terms of capturing detail in an image that might have to be used as actionable evidence.

The new HTVL Effective specification has two major benefits over existing CCTV resolution standards. For the first time, security end users, integrators, dealers, and consultants will be able to compare the actual, useable resolution of cameras using different image sensor technologies whether progressive scan or interlaced. The second benefit is that we finally have a specification that takes into consideration total captured resolution, both horizontal and vertical. Prior to this new specification, the critical contribution of vertical TV lines to high resolution CCTV video has been ignored. However, video monitors and DVRs commonly used in millions of CCTV installations fully support enhanced VTVL."

Michelle Abraham
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About the Author

Jeff Jones is director of product marketing at Pixim, Inc. and brings to the company product management experience in semiconductors and embedded systems. Prior to joining Pixim, Mr. Jones was a senior engineering director at LSI Corporation, where he was responsible for digital video solutions for consumer electronics and professional broadcast applications. Mr. Jones is a US patent holder and has a bachelor's degree in electrical engineering from the University of California, Irvine, and an MBA from California State University, Fullerton.

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