PIXIM®
EVERY PIXEL TELLS A STORY

White Paper:

Camera Resolution Is Limited to 540 HTVL Maximum in CCTV Systems

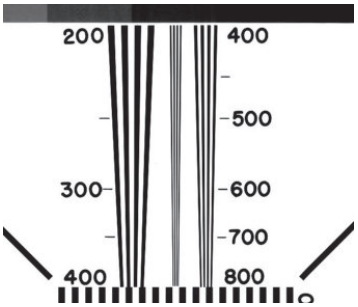
Claims of Higher Resolution Benefitting End Customers Are False

Table of Contents

Recently, manufacturers have been promoting CCTV cameras with resolution specifications higher than 540 HTVL, implying that video security customers will benefit from enhanced resolution. But it turns out that even if a CCTV camera can pass a test that validates a resolution specification over 540 HTVL, the end user is not going to get more than 540 lines out of a typical installation because of system limitations common to all real world CCTV applications.

Resolution Defined

Resolution is the ability to look at a video display and delineate detail in an image captured by a camera. In the video security market, resolution is typically specified in terms of horizontal TV lines (HTVL). Vertical TV lines are an equally important component of the total resolution but are almost never specified. Horizontal and vertical resolution can both be measured using industry standard resolution test charts and special (read "expensive"), high-resolution monitors.



Resolution test charts have "wedged" line patterns. The resolution is measured at the last point where the lines are visually discernable.

HTVL is a monochrome specification that indicates how many alternating black and white vertical lines can be captured by a camera and reproduced on a monitor screen such that they can be counted across 3/4 of the width of the display. The limitation to 3/4 of the width is because the historical aspect ratio of a traditional television monitor is 4:3, and the actual units of the measurement are TV lines per picture height which allows for a more "apples to apples" comparison of horizontal to vertical resolution. This is why resolution is specified in units of TV lines and not simply lines. Although the highest resolution can be achieved with monochrome cameras, color images are more desirable for evidentiary use, and are therefore more important from the standpoint of a video security system.

The 540 HTVL Limit

Camera manufacturers are advertising specifications of 580, 600, 650, and even 700 HTVL, and some of these manufacturers are making these claims even though they are using imaging sensors that are not physically capable of capturing more than 540 HTVL; the practical limit for analog CCTV systems. Even if these cameras were capable of capturing and delivering images with the resolutions the manufacturers are claiming, there are system limitations that prevent the end user from achieving any benefit from the advertised increase in resolution.

- **Display Monitors** – Monochrome CRTs are available with resolution specifications of up to 1000 HTVL. There are also color monitors with specifications of up to 800 HTVL when fed with an S-video signal. These are expensive monitors and not the monitors typically found in a CCTV installation. NTSC and PAL color CRTs cannot deliver more than 540 HTVL when supplied through a standard, composite video input (BNC or RCA type connector).

Model	Monochrome Resolution Spec	MSRP
Panasonic BT-H1350Y	750 HTVL	$1,790
Sony PVM14M4u	800 HTVL	$2,490
GE MVC-19HR	800 HTVL	$1,340

High resolution studio monitors, used for testing camera resolution, are expensive and only offer their highest resolution for monochrome video and at the center of the display screen.

LCD monitors are available that can display higher resolution when supplied by a high resolution source such as a personal computer or high definition disc player through an HDMI interface, but they face the same practical limits to resolution as CRTs when supplied with composite video input. Fundamentally, a composite video signal, the type provided by any analog CCTV camera, is limited to 540 HTVL because of the input circuits built into the monitor. These input circuits contain a low-pass filter which essentially throws away resolution beyond 540 HTVL in order to solve other image quality problems that are far more objectionable to the viewer than a loss of resolution such as the aliasing caused by the brick pattern in the photo below. These low pass filters are present at any analog composite input whether the display uses CRT or LCD technology.

Low-pass filters are required in order to solve image quality problems that are more objectionable to the viewer than the loss of resolution caused by low-pass filtering.

LCD monitors also have to convert the analog signal to digital format in the same manner that a DVR does which we'll explain next. The bottom line is that, if a camera actually has a horizontal resolution of more than 540 HTVL, you won't see it on any monitor that you would actually deploy. Even if you did deploy studio monitors, you would only be able to see the additional resolution before the video has been recorded on the DVR. The DVR is going to limit the resolution of the recorded video, and the recorded video is what is going to be used for evidentiary purposes; not the raw output of the camera.

Manufacturer	Model	Native Resolution	Measured Resolution (Composite input)
Dell	2700FP	1600x1200	540 HTVL
JVC	GD-19L1GL	1280x1024	540 HTVL
Samsung	LN22A450C1D (TV)	1680x1050	540 HTVL
Sony	KLVS23A10 (TV)L	1366x768	540 HTVL

In our laboratory, a number of high-resolution LCD monitors and televisions were provided with a composite video input from a high-resolution camera and measured 540 HTVL.

- **DVR Inputs** – There are no DVRs for CCTV on the market that can record more than 540 HTVL. DVRs, like display monitors, have low-pass filters at their video inputs. In order to convert the analog video signal into digital format, there is also what is known as a video decoder at their input. The conversion process samples the analog video and converts it to digital data in a industry standard format defined by ITU-R Recommendation BT.601[1] which limits horizontal resolution to exactly 720 samples per horizontal line for both NTSC and PAL (720 x ¾ = 540 HTVL). Without going deep into sampling theory, it is important to explain that this limit wasn't set arbitrarily. It was a natural consequence of the sample rate used for converting analog video to a digital format. Once again, even if a camera is capable of delivering more than 540 HTVL of resolution, it isn't going to do anything for the end user because the DVR isn't going to record it.

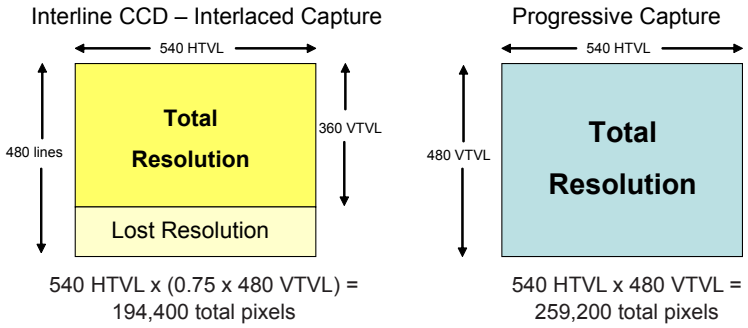
Total Resolution

Although vertical resolution is rarely specified, it is as important as horizontal resolution in calculating total resolution of an image. The total resolution of an image is simply the horizontal resolution multiplied by the vertical resolution. Until megapixel cameras were introduced, nobody talked about total resolution because certain image capture technologies are inherently limited in terms of their effective vertical resolution.

- **Interlaced Versus Progressive Image Capture** – CCD sensors like Sony's ExView Super HAD capture interlaced video using a process called line-pair summation. This acts as a low pass filter to minimize image flicker, but has a side effect of decreasing the effective vertical resolution by 25%[2]. This means that a 480 line CCD has an effective vertical resolution of 360 lines and that the image's total resolution is decreased by 25%. That's

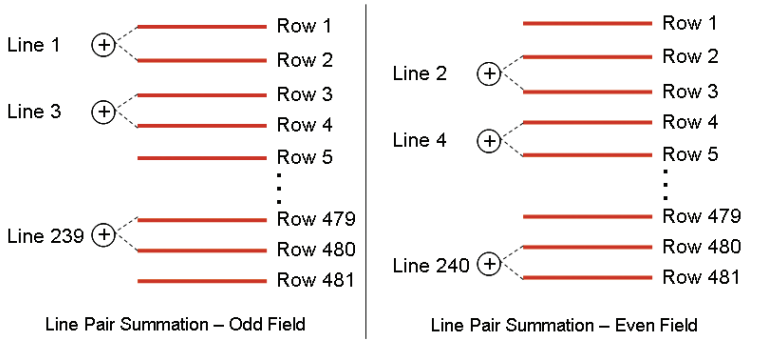
[1] http://en.wikipedia.org/wiki/CCIR_601
[2] http://broadcastengineering.com/hdtv/ccd-cmos/

A CCD uses interlaced capture, resulting in a 25% loss in resolution when compared to an imager that uses progressive capture.



unfortunate for the end user because the DVR and display monitor inputs are very capable of accepting all 480 lines of vertical resolution. Imagers that perform progressive image capture, as is the case with Pixim's Digital Pixel System® products, maintain the full vertical resolution thereby offering higher total resolution including after recording as well as on initial display.

It is important to remember that how an image is captured is independent from how it is displayed. CCTV systems typically display video in an interlaced format, but that video may have been captured by the camera in either a progressive or interlaced format. If you have a big budget and want to spend a lot of money on studio quality monitors to maximize your horizontal resolution, and if you're using CCD-based cameras that capture images in an interlaced format, then you should look for cameras with a minimum of 720 HTVL to match the total resolution of a camera that uses a 540 HTVL progressive capture sensor!



CCD sensors capture interlaced video using a process called line pair summation that eliminates flicker but throws away 25% of the vertical resolution.

Conclusion

A CCTV camera with resolution specified at more than 540 HTVL is really not going to give any additional benefit to the end user. The DVR is not going to record anything higher than 540 HTVL, and there will be no noticeable benefit when the video is displayed on a security monitor unless you spend a lot of money on a professional studio monitor and view the video before it is recorded on the DVR. On the other hand, if you buy a camera with a higher vertical resolution, such as a progressive capture Digital Pixel System camera, you will benefit from the higher total resolution because it can be captured by the DVR and displayed on mainstream CRT and LCD monitors. To find the CCTV camera that gives you the most usable resolution, look for models that have resolution specifications of 540 HTVL as well as a minimum of 450 VTVL.

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.

PIXIM®
EVERY PIXEL TELLS A STORY

1395 Charleston Road
Mountain View
CA 94043

P: 650 934.0550
F: 650 934.0560

www.pixim.com