Understanding Camera Specifications

This is the first article in the ***"Understanding CCTV Series…."***. In this series, we try and cover some of the important CCTV components and try and explain some of the issues in simple user friendly language. These articles are abstracts from STAM InSight - The Award Winning CCTV Program on CD-ROM, which has many innovative CCTV tools for skill and productivity enhancement.

We start the series with cameras. Cameras are the starting point of the video signal and are therefore a critical component of a CCTV system. The word camera comes from the Latin " camara obscura" and means "dark chamber". Artists in the Middle Ages used a dark box to trace images. Since then the camera has come a long way. Today there are three types of cameras most commonly used.

- film cameras
- photographic cameras
- video cameras

The construction and type of Charge Coupled Device (CCD) chip used in a camera is important. Some of the better quality cameras have superior chip design incorporating many innovative features like On Chip Lens (OCL), Back Light Compensation (BLC), excess charge drainage technology etc. In this article we won't look into these aspects, but try and understand some of the important camera specifications.

CAMERA SPECIFICATIONS

Any camera data sheet has a number of specifications shown like resolution, sensitivity, signal to noise ratio, camera voltage, chip type, and operating temperature. Some data sheets are detailed, while others are quite sketchy and cover the bare minimum. To classify a camera, most people will first look at the resolution and sensitivity in the data sheet. These two specifications are the most important. In this article we will discuss

these specifications in more detail. There is confusion surrounding these terms and I would like to demystify them by explaining them in simple terms.

RESOLUTION

Resolution is the quality of definition and clarity of a picture and is defined in lines

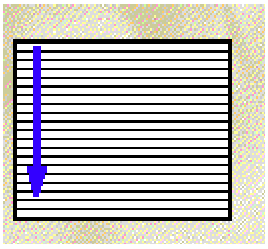
More lines = higher resolution = better picture quality.

Resolution depends upon the number of pixels (picture elements) in the CCD chip. If a camera manufacturer can put in more number of pixels in the same size CCD chip, that camera will have more resolution. In other words the resolution is directly proportional to the number of pixels in the CCD chip.

In some data sheets, two type of resolution, vertical and horizontal are indicated.

Vertical Resolution

Vertical resolution = no. of horizontal lines

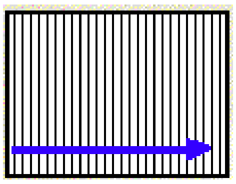


Vertical Resolution is limited by the number of horizontal scanning lines. In PAL it is 625 lines and in NTSC it is 525 lines. Using the Kell or aspect ratio factor the maximum vertical resolution is .7 of the number of horizontal scanning lines. Using this the maximum vertical resolution is

For PAL 625 X .75 = 470 lines

For NTSC 525 X .7 = 393 lines

Vertical resolution is not critical as most camera manufacturers achieve this figure.



Horizontal Resolution

Horizontal resolution = no. of vertical lines

Theoretically horizontal resolution can be increased infinitely, but the following two factors limit this

- It may not be technological possible to increase the number of pixels in a chip.
- As the number of pixels increase in the chip, the pixel size reduces which affects the sensitivity. There is a trade off between resolution and sensitivity.

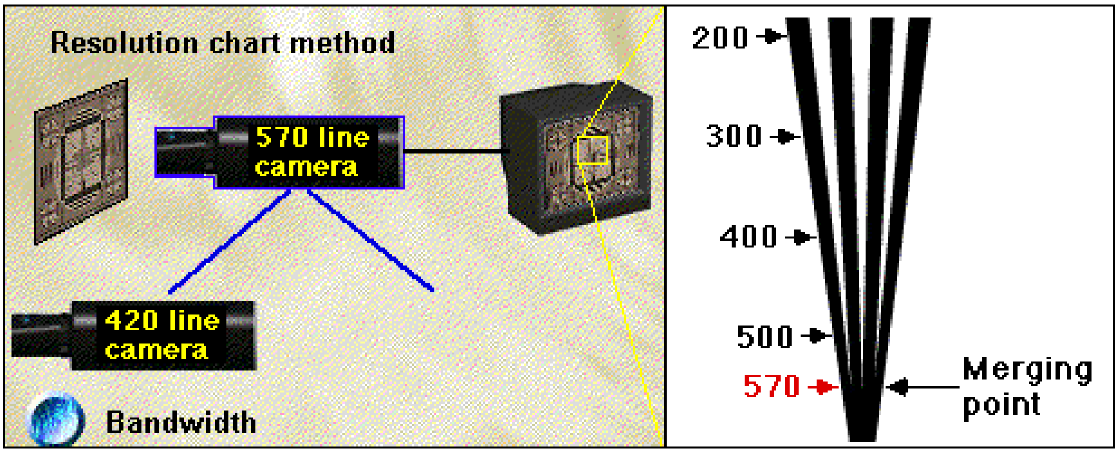
If only one resolution is shown in the data sheet, it usually is the horizontal resolution.

Measuring Resolution

There are different methods to measure resolution:

1. Resolution Chart

The camera is focused on a resolution chart and the vertical lines and horizontal lines are measured on the monitor. The resolution measurement is the point were the lines start merging and they can not be separated.



Problems

- The merging point can be subjective as different people perceive it differently
- The resolution of the monitor must be higher than the camera. This is not a problem with Black and white monitors, but is a problem with most color monitors as they usually have a lower resolution as compared with a camera.

Bandwidth method.

This is a scientific method to measure the resolution. The bandwidth of the video signal from the camera is measured on an oscilloscope. Multiply this bandwidth by 80 to give the resolution of the camera.

Example. If the bandwidth is 5Mhz, the camera resolution will be 5 * 80 = 400 lines

Typical Resolutions of Cameras

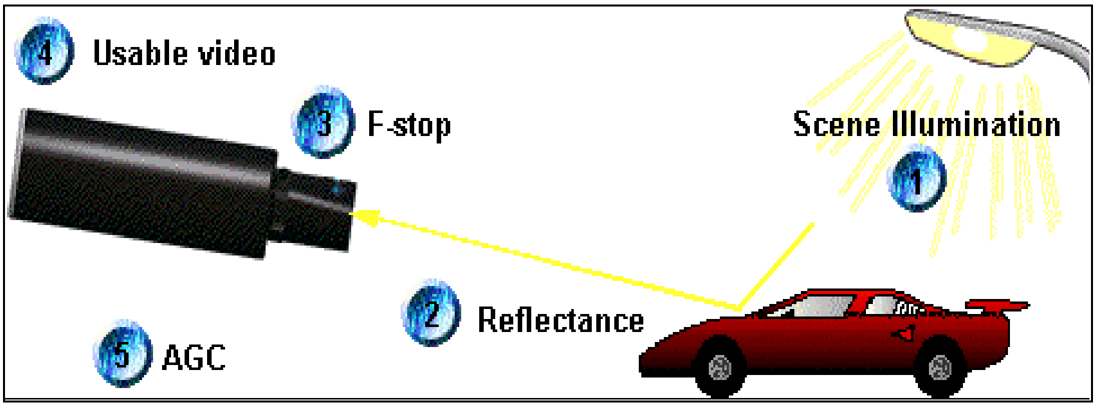
	Monochrome cameras	**Color Cameras**
Low Resolution	380 - 420 lines	330 lines
High Resolution	570 lines	470 lines

SENSITIVITY / MINIMUM SCENE ILLUMINATION

Sensitivity measured in foot-candles or lux indicates the minimum light level required to obtain an acceptable video picture.

There is a great deal of confusion in the CCTV industry over this specification. There are two definitions “sensitivity at faceplate” and “minimum scene illumination”.

- Sensitivity at faceplate indicates the minimum light required at the CCD chip to get an acceptable video picture. This looks good on paper, but in reality does not give any indication of the light required at the scene.
- Minimum scene illumination indicates the minimum light required at the scene to get an acceptable video picture. Though the correct way to show this specification,
- it depends upon a number of variables. Usually the variables used in the data sheet are never the same as in the field and therefore do not give a correct indication of the actual light required. For example a camera indicating the minimum scene illumination is 0.1 lux. Moonlight provides this light level, but when this camera is installed in moonlight, the picture quality is either poor or there is no picture. Why does this happen? It is because the field variables are not the same as those used in the data sheet.



How does it work? Usually light falls on the subject. A certain percentage is absorbed and the balance is reflected and this moves toward the lens in the camera. Depending upon the iris opening of the camera a certain portion of the light falls on the CCD chip. This light then generates a charge, which is converted into a voltage. The following variables should be shown in the data sheet while indicating the minimum scene illumination.

- Reflectance
- F Stop
- Usable Video
- AGC
- Shutter speed

Reflectance

Light from a light source falls on the subject. Depending upon the surface reflectivity, a certain portion of this light is reflected back which moves towards the camera. Below are a few examples of surface reflectivity.

Snow = 90%

Grass = 40%

Brick = 25%

Black = 5%

Most camera manufacturers use an 89% or 75% (white surface) reflectance surface to define the minimum scene illumination. If the actual scene you are watching has the same reflectance as in the data sheet, then there is no problem, but in most cases this is not true. If you are watching a black car, only 5% of the light is reflected and therefore at least 15 times more light is required at the scene to give the same amount of reflected light. To compensate for the mismatch, use the modification factor shown below.

Modification factor F1 = Rd/Ra

Rd = reflectance used in the data sheet

Ra = reflectance of the actual scene

Lens Speed

The reflected light starts moving towards the camera. The first device it meets is the lens, which has a certain iris opening. While specifying the minimum scene illumination, the data sheet usually specifies an F-Stop of F1.4 or F1.2. F-Stop gives an indication of the iris opening of the lens. The larger the F-Stop value, the smaller the iris opening and vice versa. If the lens being used at the scene does not have the same iris opening, then the light required at the scene requires to be compensated for the mismatch in the iris opening.

Modification factor F2=- Fa^2 / Fd^2

Fa = F-stop of actual lens

Fd = F-stop of lens used in data sheet.

Usable Video

After passing through the lens the light reaches the CCD chip and generates a charge, which is proportional to the light falling on a pixel. This charge is read out and converted into a video signal. Usable video is the minimum video signal specified in the camera data sheet to generate an acceptable picture on the monitor. It is usually measured as a percentage of the full video.

Example: 30% usable video = 30% of 0.7 volts (full video or maximum video amplitude) = 0.2 volts. The question here is: Is this acceptable?

Unfortunately there is no standard definition for usable video in the industry and most manufacturers do not indicate their definition in the data sheet while measuring the minimum scene illumination.

It is recommended to be aware of the useable video percentage used by the manufacturer while specifying the minimum scene illumination in the data sheet. The minimum scene illumination should be modified if the useable video used in the data sheet is not acceptable.

Modification Factor F3 = Au/Du

Au = actual video required at the site as % of full video

Du = usable video % used by the manufacturer

AGC

AGC stands for Automatic Gain Control. As the light level reduces the AGC switches on and the video signal gets a boost. Unfortunately, the noise present also gets a boost. However when the light levels are high, the AGC switches off automatically, because the boost could overload the pixels causing vertical streaking etc.

The data sheet should indicate if the AGC is On or Off while measuring minimum scene illumination. If the data sheet indicates AGC is "on" yet, if in reality the AGC is "off" then the minimum scene illumination in the data sheet should be modified

Modification Factor F4 = Ad/Aa

Ad = AGC position in the data sheet

Aa = Actual AGC position

If AGC off = 1, then AGC on = db figure from the data sheet

Shutter Speed

These days most cameras have an electronic shutter speed, which allows one to adjust the timing of the charge, read of the CCD chip. The standard read out is 50 times (PAL) and 60 times (NTSC) per second. If the shutter speed is increased to say 1000 times per sec, that means the light required at the scene should be 20 times more (for PAL). Increasing the shutter speed allows the picture to be crisper, but requires more light. Use the following modification factor

Modification Factor F5 = Sa/Sd

Sd = Default shutter speed (PAL - 1/50 sec NTSC - 1/60 sec)

Sa = Actual shutter speed being used

Adjusted Minimum Scene Illumination

The minimum scene illumination of the camera must be adjusted because of the mismatch between the actual conditions in the field and the variables used in the data sheet.

Ma = (F1*F2*F3*F4*F5) * Md

Ma = adjusted minimum scene illumination

Md = minimum scene illumination as per the camera data sheet

Comparison

Compare the actual light at the scene (L) with the adjusted minimum scene illumination (Ma). If the light available is more than the adjusted minimum scene illumination, then the current camera can be used. If the actual light at the scene is lower than the adjusted minimum scene illumination of the camera, then the camera setting may require adjustment or an alternative solution is necessary. The following steps will help resolve the issue.

Step 1

Check if camera variables can be changed

- If AGC is switched off, then switch AGC on
- Accept a lower usable video %
- Reduce shutter speed, if possible
- Use a lens with a lower F-stop
- If no success go step 2

Step 2

- Find a more sensitive camera
- Down grade from color to B/W camera
- Add Infrared light if B/W camera is being used
- Add more lighting at the scene

Example

It maybe worth while to study an example so that all the above concepts can be understood correctly. Let us assume that the camera is focussed on green grass (20% reflectivity). The actual light level at the scene is 50 lux. The colour camera data sheet indicates the minimum scene illumination is 2.5 lux. The table below compares the variables as indicated in the data sheet and also the actual situation in the field.

Parameter	Data Sheet	Actual	Factor
Reflectivity	89%	20%	4.45
F Stop	1.2	1.4	1.36
Usable Video	30%	100%	3.3
AGC	On	On	1
Shutter Speed	1/50 sec	1/50 sec	1
Minimum Scene Illumination	2.5 lux	?	
Actual Light level		50 lux	

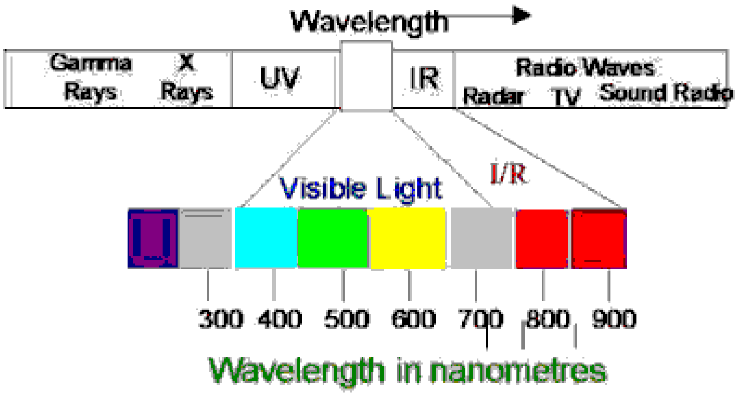
Modified Minimum Scene Illumination = (4.45* 1.36 * 3.3 * 1 * 1) * 2.5 = 45 lux

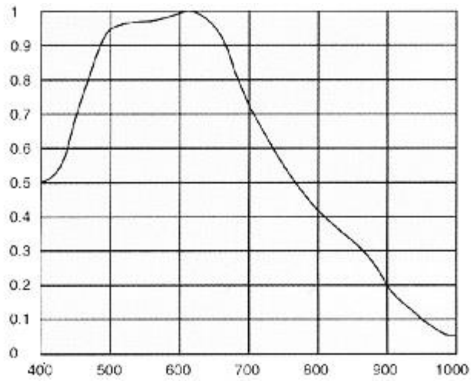
This camera would work, as the light level at the scene (50 lux) is higher than the modified minimum scene illumination of the camera (45 lux).

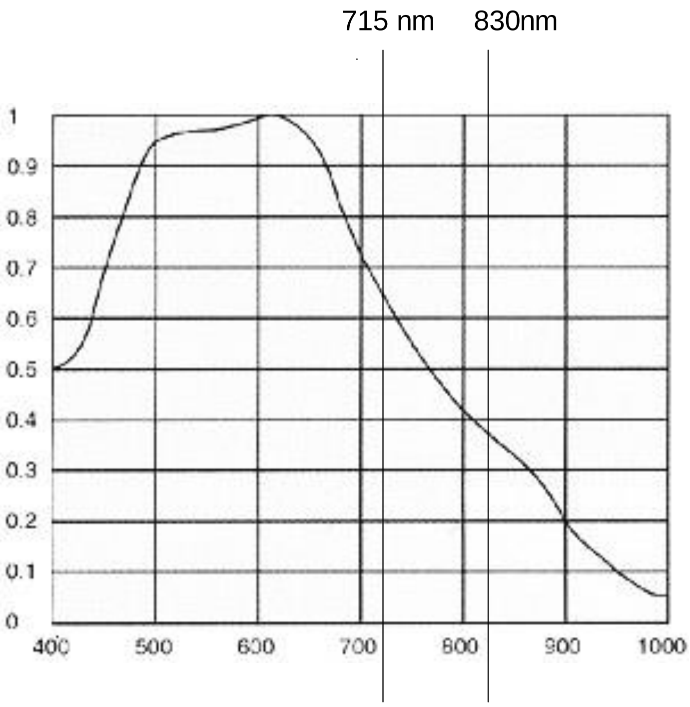
About the Author

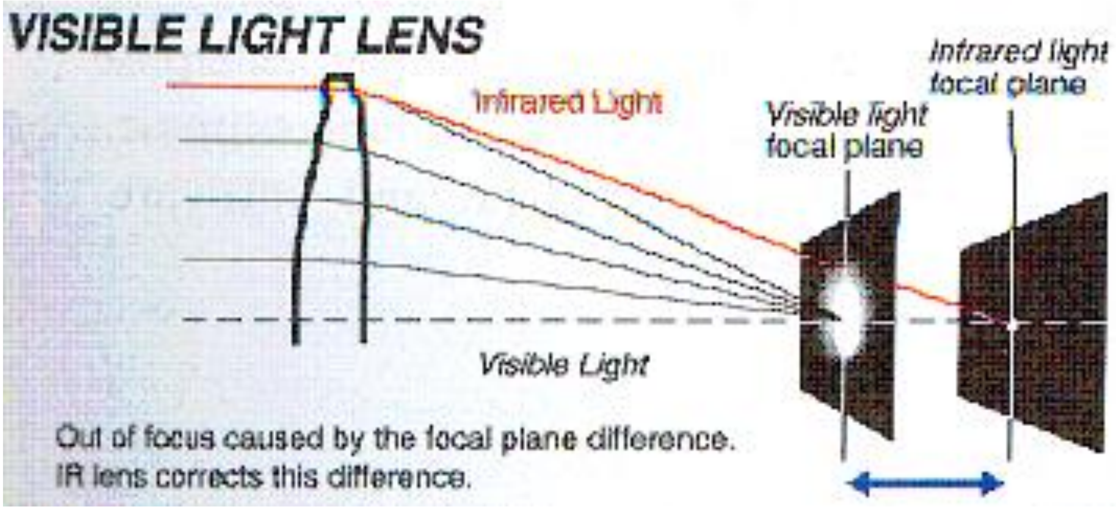
Jayant Kapatker is an international authority on CCTV and is the brain behind STAM InSight - The Award Winning CCTV Program on CD-ROM. This interactive multimedia CD-ROM contains over 14 hours of CCTV content. This series of articles have been based upon the subjects covered in STAM InSight. For more info on the CD ROM contact INSTROM Tel: 01908 261900 Fax: 01908 261933,
E-mail: enquiries@instrom.co.uk or visit our website: www.instrom.co.uk

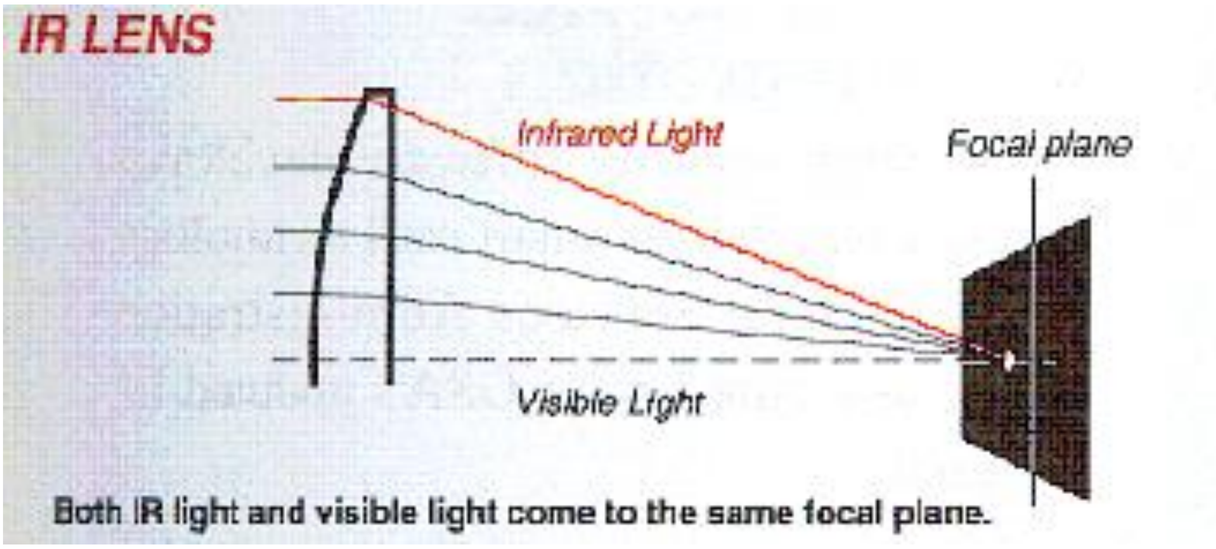
Camera Wavelength Response








VISIBLE LIGHT LENS
Infrared light focal plane
Infrared Light
Visible light focal plane
Visible Light
Out of focus caused by the focal plane difference.
IR lens corrects this difference.


IR LENS
Infrared Light
Focal plane
Visible Light
Both IR light and visible light come to the same focal plane.