A GUIDE TO LENS SELECTION

AC (= Alternating Current)

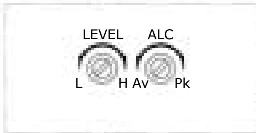
AC is the English designation for alternating current meaning an electrical current whose magnitude and direction vary opposed to direct current (DC).

Household current is in general alternating current.

ALC (Automatic Light Control)

Auto-Iris lenses gain their reference from the video signal produced by the camera. The measuring method to control the Auto-Iris is set by measuring the entire image. If the aperture of the lens is reacting too much to bright areas such as car headlights, you can adjust the lens potentiometer to compensate.

Monitor image	Turning direction of the ALC potentiometer
less contrast	turning clockwise to (Pk)
more contrast	turning anti-clockwise to (Av)



Av = Average
Pk = Peak

Please note:
- Setting to an extreme value can impair the picture.
- It is possible that lenses ALC settings may have problems with some digital cameras due to backlight compensation and AGC.

Aspherical lenses

Due to the shape of the glass in an aspherical lens more light is able to be focused onto a cameras CCD. This is how PENTAX aspherical lenses are able to make cameras work in lower light conditions than standard lenses. For colour cameras this is a particular advantage as they can struggle in lower light conditions and so need all the light available. The picture will then have less interference (noise), it will have better colour reproduction and will help the camera produce a better video signal. When used with high sensitivity mono cameras many applications won't require any form of man made lighting and can cope with only the most limited natural light. Also, the more light transmitted by the lens can only mean better image sharpness and less distortion at the edges of the picture.

Back focal distance

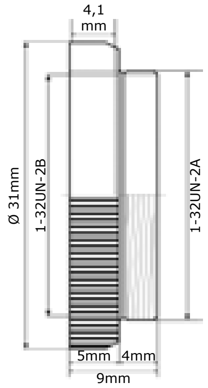
In CCTV we use two different standardised measures of lens mounting, **C-Mount** which has a back focal length of 17.526mm and **CS-Mount** which has 12.5mm. This is the distance from the last surface of a lens to the cameras CCD sensor.

Due to very small tolerances in the correct alignment of the lens projection, many CCTV cameras have movable (or racking) CCD chips.

The adjusting of the cameras CCD chip (called back focusing) always needs to be performed with the lenses aperture fully open. Opening the aperture on Auto-Iris lenses can be achieved with the help of ND filters, by disconnecting the video signal from the lens but keeping the power supply connected and speeding up the camera's shutter speed.

As a rule-of-thumb for a point at infinite (∞) distance the focal length of the lens will be multiplied by 2000, e.g. a 50mm lens should be set up at a distance of 100m.

1. C-, CS-Mount thread



The C and CS mount connection is a one inch thread with a specification 1-32UN-2A or B or W 1 inch x 32TPI (TPI = Thread per inch) and almost corresponds with the metric thread M25.5 x 0.75 mm. The angle of light projection for the one inch thread is 55°. However, the metric thread is 60°.

By using a C80035 C/CS Mount adapter, a C mount lenses can be used on CS mount camera, but it's not possible to use a CS mount lens on a C mount camera.

2. Aligning the back focus

To adjust (rack) the cameras CCD sensor in order to back focus the lens, please refer to the camera manufacturer's instruction manual. This adjustment will always need to be performed when installing a fixed focus lens.

3. Back focal length adjustment for zoom lenses

When using motorized zoom lenses it is always necessary to back focus the camera in order for the lens to be able to properly track focus.

Please read the "Aligning the back focus" paragraph before continuing.
1. Align the camera on a target object at sufficient distance (ideally a distant object)
2. Set the focus (distance) of the lens to ∞ (infinitely).
3. Set the zoom range to the shortest focal length (wide angle).
4. Now adjust the cameras back focus until the image on the monitor is in perfect focus.
5. Now adjust the zoom range to the largest focal length (Tele).
6. Re-adjust the focus by means of the focus ring of the lens.
7. Re-adjust the zoom range to the shortest focal length (wide angle).
8. Re-adjust the back focus on the camera until you again have the image in focus.
9. Repeat steps 3 to 8 until the lens produces continuous focus over the whole zoom range.

4. Back focusing for Vari-focal lenses

Installation of our CS-Mount Vari-focal lens shouldn't need adjustment of the cameras CCD. If the chip has been moved from it's default position you can return it by mounting a fixed focal length lens to the camera, set the focus to ∞ (infinity), aim at a distant object and adjust the back focus until the picture is in focus.

5. Back focusing for Auto-Iris lenses

Open the lenses aperture by disconnecting the video signal to the lens and speeding up the cameras shutter speed, or by using a neutral density filter (ND). Now set the focus ring to ∞ (infinitely) and adjust the back focus accordingly.

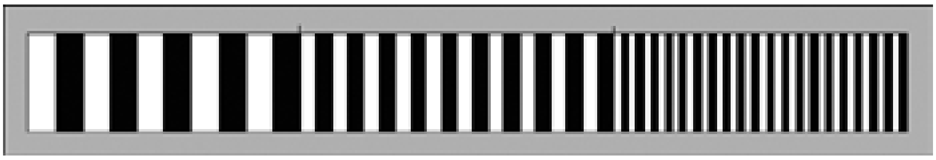
6. Back focusing for manual lenses

Fully open the lenses aperture. Adjust the focus ring to ∞ (infinity) and adjust the cameras back focus. After setting the back focus, close the aperture until you achieve the required depth of field.

Resolution (modulation transfer function)

With the help of a test chart with graduating resolution lines you can measure the quality of the optics. You will see that the image produced will become poorer the closer to the edges you get. This is the nature of both the lens and the CCD within the camera as the highest optical performance of a lens and CCD is in the middle.

Image quality can also help significantly with the picture contrast as a higher quality lens and CCD have better focus between dark and bright areas of the image.



Angle of view

The angle of view is the area shown on screen. The angle is determined by the lenses focal length and the corresponding CCD.

Aperture

The aperture is the reduction in light through the lens caused by the many mechanics and pieces of glass necessary to focus the image. By adjusting the cameras shutter speed you can adjust the brightness of the picture electronically. It is sometimes necessary to adjust the aperture and/or the shutter speed in order to capture the relevant target. The size of the aperture (K) is calculated by taking the focal length ratio (F) and dividing it by the diameter of the iris opening (D).

$$k = \frac{f}{D}$$

Aperture values are international standards. The aperture levels change at a factor of $\sqrt{2}$. On the below chart, from one aperture rating to the next, the amount of light doubles or halves, depending on which direction you are going. So, from an aperture of F8 to F16 the quantity of light will reduce to one quarter.

Large aperture (fast) Small aperture (slow)

0.7 | 1 | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 | ... | 360 | 512 | 720 | 1000 | 1500 | 2000 | 3000

A common rating with our lenses is F1.4 - F360 which means that with the iris fully open it is operating at F1.4 and with it closed down as far as it will go (and the use of the built in neutral density filter) the aperture is F360.

For zoom or vari-focal lenses F1.4 only signifies the light intensity at full wide angle. A correct indication should be for instance F1.4 - F2.8. The second aperture value is the light intensity which can be achieved when the lens is at the extended telephoto range.

When using a 2x focal length extender the aperture will also double. So our 12-600mm zoom lens has an aperture of F4.0 at 12mm, but with the 2x extender in place this would become F8.0.

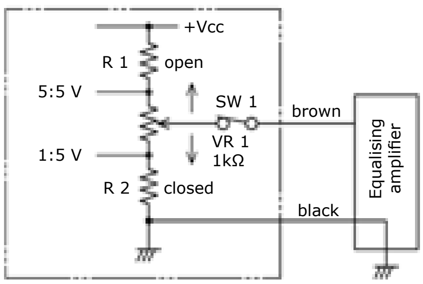
Remote control of aperture

Zoom lenses with an **F** in its designation (e. g. H20ZAME-5**F** (WX)) and Auto-Iris fixed focal length lenses with **ER** (e. g. H1212**ER**) are equipped with iris override.

Certain applications require the need to be able to control the opening and closing of the iris. An example is sporting events when large flood lights are used, these can cause the iris to close down making the darker areas unusable. In this instance the operator can the open the iris up allowing more light from the darker areas to enter the lens.

Our monofocal iris override lenses (without D/A Converter) can be controlled remotely as per the following simple circuit.

The iris override is controlled via a standard voltage circuit:



Input voltage (Vcc)	Function
open or ground	auto iris
closed	manual override

Input voltage (Vcc)	Resistance (R1) - KΩ	Resistance (R2) - KΩ
13.0 V	1.8	0.33
12.5 V	1.6	0.33
12.0 V	1.5	0.33
11.5 V	1.3	0.33
11.0 V	1.3	0.33
10.5 V	1.2	0.33
10.0 V	1	0.33
9.5 V	0.91	0.33
9.0 V	0.82	0.33
8.5 V	0.68	0.33
8.0 V	0.58	0.33
7.5 V	0.47	0.33
7.0 V	0.33	0.33
6.5 V	0.22	0.33
6.0 V	0.1	0.33
5.5 V	0	0.33

Iris override with D/A converter

Certain zoom lenses are equipped with a D/A converter (Digital/Analogue converter). The D/A converter is controlled directly by a 12V voltage. When you change the polarity, the iris will open or close accordingly. As soon as the iris override is deactivated the iris will go back to automatic and take its reference from the video signal. If the iris override is reactivated again, the iris will revert to the last saved position.

Calculation of focal length

As described above, the angle of view is a directly related to the lenses focal length. This can be calculated using the following formula:

$$\frac{w}{W} = \frac{f}{D} \quad \text{or} \quad \frac{h}{H} = \frac{f}{D}$$

w = width of the CCD sensor
W = width of the object

h = height of the CCD sensor
H = height of the object

f = focal length
D = object distance

1. To calculate the required lens focal length, please see the following examples:

1.1 The following calculation is using a 1/2" camera which has a sensor width of 6.4mm. If looking at a gateway (for example) with a width of 10m at a distance of 25m.

$$\frac{w}{W} = \frac{6.4mm}{10000mm} = \frac{f}{25000mm} = 16mm \text{ focal length}$$

Or

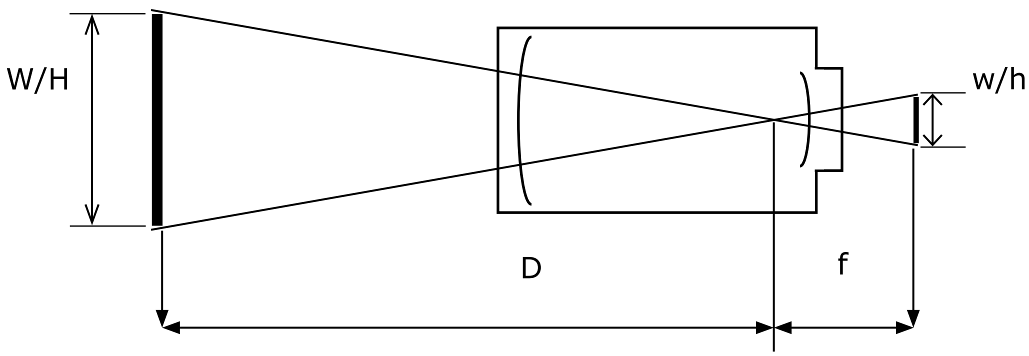
1.2 Using a 1/3" sensor with a height of 3.6mm. An area with a height of 4.5m at a distance of 10m needs to be monitored.

$$\frac{h}{H} = \frac{3.6mm}{4500mm} = \frac{f}{10000mm} = 8.0mm \text{ focal length}$$

2. If there are already cameras and lenses being used and you need to work out the distance required between camera and the object.

2.1 A 1/3" camera with a sensor width of 4.8mm being used and a lens with a focal length of 2.8mm is monitoring a gate of a width of 4.5m.

$$\frac{w}{W} = \frac{4.8mm}{4500mm} = \frac{2.8\ mm}{D} = 2.6m \text{ distance (rounded)}$$



CCTV

Closed Circuit Television

D/A (motorised zoom lens with iris override and D/A converter)

See Iris Override section

DC (= Direct Current)

DC is the English designation for direct current. When direct current is being used, the polarity remains constant, e.g. batteries deliver direct current. This is opposite to alternating current (AC)

DC Iris

Lenses with a DC controlled auto-iris are controlled by cameras with a built-in amplifier. Although cheaper to produce than Video controlled irises, DC irises are slower to respond and can be less accurate.

Immersion depth (protrusion) <= 4.0mm

3 CCD cameras often require lenses with a rear optic penetration depth of less than 4.0mm.

EMC/EMV

If a CCTV system is combined with an alarm system, the lenses will need to comply to EMC/EMV directives EN50130-4/A1 (since January 1st, 2001). All electrically controlled lenses made by PENTAX comply with these directives.

Colour correction

Lenses where the RGB (red green blue) spectral components have been corrected are called achromatic lenses. When a lens is corrected for use with RGB and into the near infrared range they're called superachromatic lenses

Filter

- ND filter
  An ND2 filter reduces the light transmission by half (50%), an ND4 filter reduces it to a quarter (25%) and an ND8 filter reduces it to one eighth (12.5%) of the original light quantity.

- UV cut filter
  UV filters block UV-light from entering the lens, but they allow visible and IR light to pass through. Often UV filters are used to protect the valuable front optics of lenses.

- Polarising filter
  Polarising filters are used to eliminate reflections which can come from window, water etc. The filter is attached to the end of the lens and rotated until it blocks out the required reflection.
-

Lock screws

Due to our manual iris lenses being used in many applications involving automated and mechanical moving parts such as production lines and factory robots, we have developed this style of lens to have lockable focus and iris rings to prevent vibration from shifting then.

KA = one set screw on each focus and iris rings
KG = one thumb screw on each focus and iris ring
KP = three set screws and one thumb screw on each focus and lens ring

Fixed focus lens

Fixed focus lenses have their focus adjusted by way of the camera's back focus and can be used in close up applications with close up rings.

Focus

Setting up the focusing of a lens is always more accurate when it is done with the iris open and the depth of field at it's minimum. When the iris is then closed down the image can only get sharper.

Focus shift

Focus shift can happen as white light travels through the optics of a lens differently to IR light and so has a different focus point. This means that during the day the lens can be in focus but when the white light recedes and IR light is more prevalent, the image focus will shift.

IR corrected lenses resolve this by readjusting the alignment of the IR light travelling through the lens so that it has the same focal point as white light.

Format: 1/4'', 1/3'', 1/2'', 2/3'', 1''

Format refers to the diameter of the circle of light the lens projects and is designed to coincide with camera CCD sizes. Lenses of a larger format will work with smaller CCD's but not vice versa.

The lens's angle of view is specified with the use of a corresponding sized CCD in mind, so if you use a larger format lens on a smaller CCD, the angle of view will be affected. As an example using a 2/3'' lens on a 1/3'' camera will narrow the angle of view by approximately half, so a 50° angle would then reduce to 25°.

Backlight

Backlight refers to bright areas of light that are behind the area or object being viewed. This can cause problems by making the area or object in the foreground appear darker.

Ghosting

Ghosting is when a second or reflection of the original image appears in the picture.

There are a couple of causes of ghosting. One can be poor quality lenses picking up reflections, but in most instances it is caused by faults within the cabling such as incorrect termination or a shorted coax.

High-resolution

Lenses are determined to be of **high resolution** if they can display a larger number of line pairs per millimetre at higher contrast (measured against the current standard) than a standard lens (see also: resolution MTF). High-resolution lenses reproduce images more accurately than a standard lenses. In particular, even with low levels of illumination you can still generate high-contrast images.

Infrared (IR) coated lenses

When using cameras with extremely high IR sensitivity, the picture often includes flare and appears washed out, due to the CCD sensors sensitivity to a large range of different wave lengths. IR-coated lenses correct the situation by increasing the transmission of light between the wavelengths 700 and 900nm.

Conventional lenses are optimised for a wave length of about 550nm. At these wave lengths, the standard CCD chip is highly sensitive. Wavelengths below 450nm and above 650nm (where the sensitivity of a lens steeply declines) will be largely ignored in producing the final picture.

IR-coated lenses are coated to increase transmission of light in the working range of about 850nm. This way, the characteristic curve of the infrared camera will be perfectly supported and will generate its picture mainly of the infrared light contained in daylight and by night with the addition of IR illumination.

Infrared cut filter

An IR cut filter cuts out IR (700nm+) light but allows visible white light to pass to the cameras CCD.

Many of our lenses come with an IR cut spot filter. This is a very small area at the very centre of the lens which only works when the iris closes right down in bright light. This way during bright periods the iris will close down and the lens will then block out IR light keeping colour rendition high, but when artificial IR light is present the iris will remain open and the lens will let the light in.

Ingress Protection (IP)

An IP rating is given to a protective housing or casing and is used to protect components (in this case CCTV cameras) from dust and water. The abbreviation IP is followed by two numbers, the first indicates the protective qualities against solid objects such as dust and the second number represents water ingress. The higher the number, the greater the protection.

Object Protection	Water Protection
0 Non-protected	0 - Non-Protected
1 - Protected against solid objects greater than 50 mm	1 - Protected against dripping water
2 - Protected against solid objects greater than 12 mm	2 - Protected against dripping water when tilted up to 15°
3 - Protected against solid objects greater than 2.5 mm	3 - Protected against spraying water
4 - Protected against solid objects greater than 1.0 mm	4 - Protected against splashing water
5 - Dust protected	5 - Protected against water jets
6 - Dust-tight	6 - Protected against heavy seas
	7 - Protected against the effects of immersion
	8 - Protected against submersion

Example:

A housing with the rating IP54 means that the housing protects against dust and rain, but would not be suitable for very dusty environments or where there is spray from the sea etc.

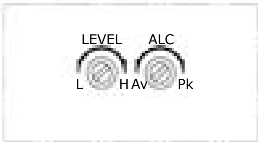
Advice:
The above chart is designed for guidance only.

Level

Video drive lenses receive a reference signal from the camera and the lens opens and closes the iris accordingly to control the light. As every camera is different all video drive lenses have a level adjustment (known as a pot) on the side to adjust the sensitivity of the lens to the camera for any given scene.

Monitor screen	Turning direction of the LEVEL poteniometer
Clearer screen - higher LEVEL (High)	Turning clockwise to (H)
Darker screen – lower level LEVEL (Low)	Turning anti-clockwise (L)

H = High, larger aperture opening = brighter screen
L = Low, smaller aperture opening = darker screen



Please note:

- The adjustment to the extreme setting can reduce the quality of the picture or lead to malfunctions of the automatic aperture control
- In order to achieve the best results in adjusting the level, we recommend you direct the camera to a high contrast (bright) area in order to then adjust the level.
- Ensure the camera's back light compensation and AGC are switched off, otherwise these can counter the adjust- ment of the level.

Macro Focus Mount (MUM-2, MUM-2M)
The Macro Focus Mount is a special camera mount with a 2mm tube extension. The C-Mount back focal length will be extended by 2mm to 19.526mm which will in turn reduce the lenses minimum object distance (MOD). In order to use our Macro Focus Mount, remove the standard C-mount on the lens and replace with the appropriate mount above. Please ensure you use the correct mount to lens as per the above chart. The C80057 is designed for all the machine vision lenses except the C37500KP. In order to achieve even higher magnifications you can also use the close up adaptors and extension tubes.

Meridional

Refer to sagittal

MOD (Minimum Object Distance)

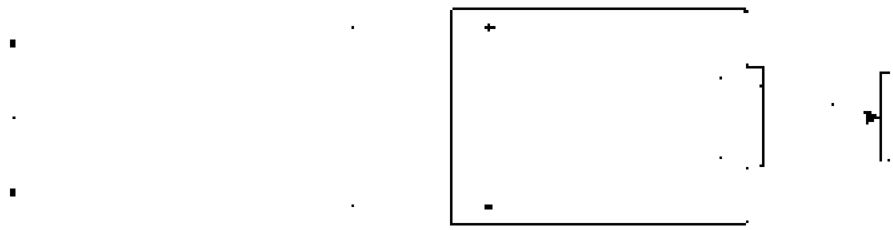
The minimum object distance refers to the minimum distance from the front of the lens that an item will remain in focus. To reduce a lens's MOD you can install extension tubes and spacers between the lens and the camera which moves the lens further away from the CCD. The further the lens is from the CCD the closer the MOD. Please note reducing the MOD of a lens in this way affects focus at longer distances.

MTF (Modulation Transfer Function)

See resolving capacity

Close-up lenses

Close-up lenses are used to reduce the MOD of lenses so that items close to the front optic can remain in focus. Focal lengths of 250mm, 333mm, 500mm and 1000m are available and screw in to the lens's front filter thread.



Focal lengths of close-up lens =
Accuracy level at infinity position of the lens

OTF (Optical Transfer Function)

See resolving capacity

Protrusion

See Immersion depth

Radial

See sagittal

Preset Potentiometer

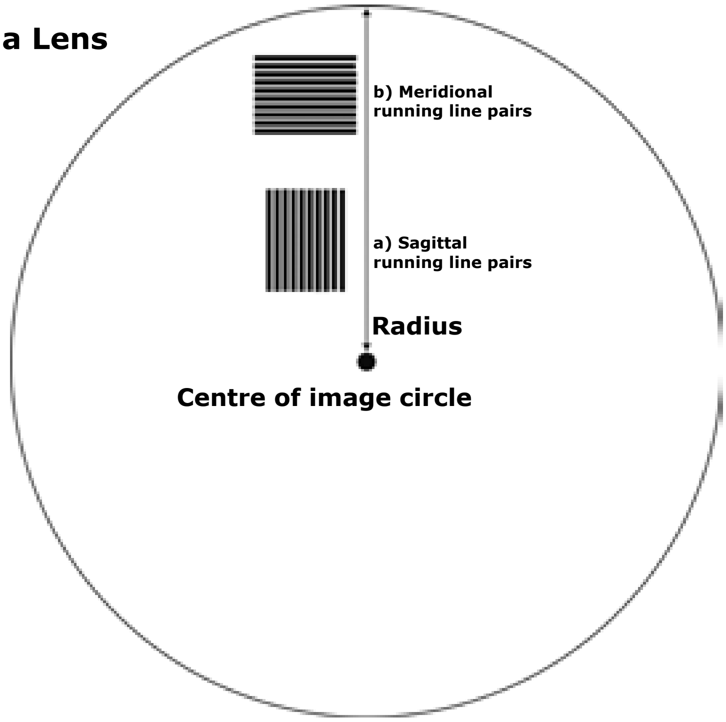
In order to use preset positions with zoom lenses, the lens has to have preset potentiometers built in which send a feedback voltage to the control equipment. This allows the lens to return to a pre determined position or go on a preset walk.

Sagittal (resolving capacity)

For measuring lens resolution with the help of MTF, sets of fine repeating lines are created parallel to a diagonal line running from corner to corner of the image area directly through the center of the image. These are called Sagittal lines. At a 90° angle to these additional sets of repeating lines are drawn, called Meridional line sets. Repeating extremely fine short parallel lines spaced at 30 lines per millimetre measure the lens ability to record fine details, or its resolution.

a) Sagittal (or radial) line pairs are running parallel to the radius
b) Meridional (or tangential) line pairs are running at a right angle to the radius

Display Circle of a Lens



Depth of field

Depth of field refers to the length of area that is in focus within the image. Usually, the shorter the focal length the greater the depth of field.

Tangential

See sagittal

Day/night lenses (D/N lenses)

This series of lenses are designed to be used with IR-sensitive colour cameras (day/night cameras). During the day colour reproduction remains unaltered and at night these lenses, due to there optical arrangement, focus IR and White Light at the same point creating no discernable focus shift. These lenses are also recommended for b/w cameras which reproduce high IR-reflecting surfaces such as grass and foliage particularly well.

Lens Transmission

The transmission of a lens indicate what wave lengths of light can be passed through to the cameras CCD. The usual transmission is from about 300nm up to 1200nm.

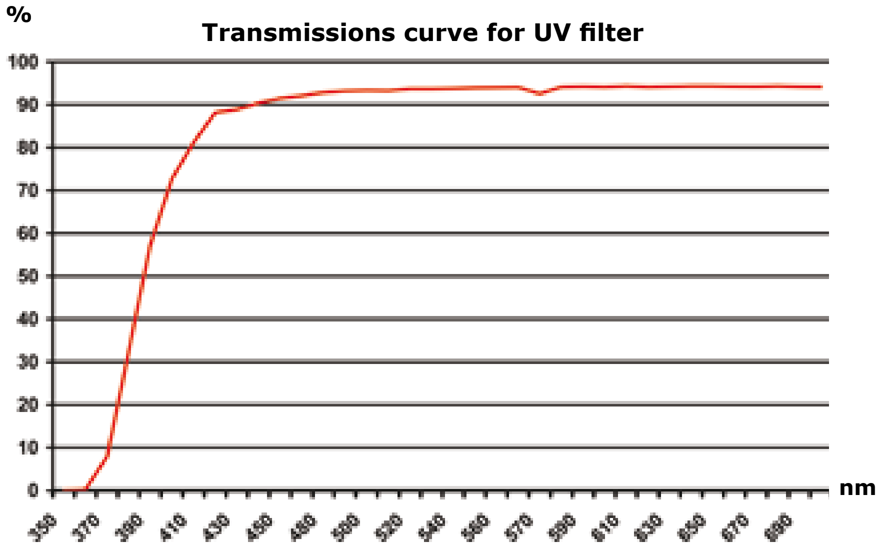
Reversing ring (for microscopy)

A reversing ring screws to the front filter of a corresponding lens and allows you to attach it to the camera in reverse. This creates an extremely short MOD and can allow the lens to focus only millimetres from an object.

In the download area of our website you will find a PDF table with lenses and the corresponding magnification factors when using reversing rings.

UV filter (UV = ultraviolet)

UV filter are designed to block UV-light and pass visible light. Often UV filters are used to protect the valuable front optic of a lens.



Vari Focal Lens

Vari Focal lenses allow infinite variations of focal length within a set range and therefore change the angle of view displayed on the monitor. In general, vari focal lenses have a much smaller range of focal length than zoom lenses, but have much wider angles of view. Furthermore, when the focal length is adjusted the focus mechanism must also be adjusted to maintain optimum focus (except: Pan-Focus Vari focal lenses). Therefore, vari focal lenses are often used in the place of monofocal lenses because they have the advantage of allowing you to adjust the angle of view once you are on site.

Due to their design, vari focal lenses can be offered at lower prices than zoom lenses or lenses of corresponding fixed focal length. PENTAX vari focal lenses provide this without any depreciation in picture quality.

Equalising (EE) amplifier

For lenses with integrated equalising (EE) amplifier (aperture control: VS), the video signal (VS) delivered by the CCTV camera is monitored by the equalising amplifier and used to adjust the aperture of the lens. If light levels are low, the video signal level is low and the equalising amplifier opens the aperture. With increasing brightness, the video signal level increases and the equalising amplifier closes the aperture accordingly.

If the equalising amplifier is integrated in the camera, you can use lenses without equalising amplifier (aperture control: DC). These lenses are called DC-controlled, tension-controlled or directly controlled (direct drive) lenses. Simply said, the video signal will be analysed by the camera and the camera sends out a DC voltage to the lens which in turn adjusts the aperture.

Coatings (anti-reflection coatings)

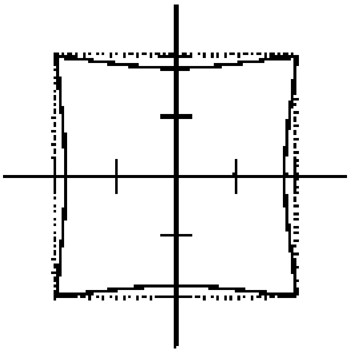
High-quality coatings reduce scattered light inside the optics of a lens. Reflections inside the optic cause a series of undesired effects: for pictures with a high intensity of illumination (e.g. due to the light source itself or solar radiation), nebular, punctual reflections and shading are being generated.

For nebular reflections, low-contrast images (e.g. people in the shade) can no longer be displayed due to the loss of contrast. This decrease in contrast and the appearance of light spots in the picture greatly influence the reliability of video sensors which finally produce false alarms or cannot reliably detect people on the picture who are dressed in a similar way. For CCD sensors, single clear reflexes lead to phantom images which can pass over the whole picture. Punctual overloading will lead to the typical „smear" effect on the CCD sensor. Another very important item is the abrasion resistance of the coating. After each cleaning of the lens surface, the coating should neither be rubbed off, nor should it's thickness be changed. Only extensive pre-treatment of the glass surfaces guarantees a long service life of the razor thin coating.

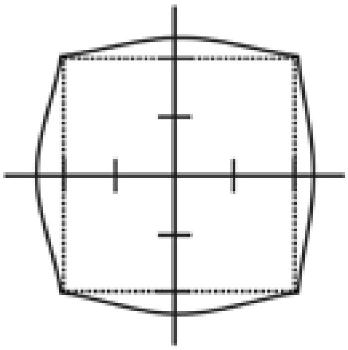
Distortion

It is one of the properties of lenses to produce more distortion towards the image border. Straight lines close to the image border are bent outwards or inwards (distorted). It is called barrel distortion when the lines are bowed outwards and pin cushion distortion when the lines are bowed inwards (see figures below). In general, you can say that a lens with a little distortion is of a higher quality than a lens with a higher distortion.

Pin Cushion Distortion



Barrel Distortion



Video signal

The video signal is a signal in which the luma signal, chroma signal and synchronization signal are all embedded together in a single signal. The luma signal (or luminance) contains the intensity (brightness or darkness) information of the image. The chroma signal contains the colour information of the image. The synchronization signal controls the scanning of the signal on a display or on a recording device. It can transmit b/w as well as colour pictures. Video standard (CCiR 1v p-p)

Vignetting (decrease of ambient light)
Vignetting is a reduction of an image's brightness or saturation at the periphery (image borders) compared to the image center. Vignetting becomes more visible if your image is of a uniformly illuminated clear wall or if a cloudless sky is viewed on a high-quality monitor without any border shading. You can reduce the effects of vignetting by stopping down the lens.

Video Iris

Lenses with VS (video signal) controlled iris incorporate an equalising (EE) amplifier. The lens connects directly to the camera via an auto iris lead, which provides both power and the video signal to the lens. The sensitivity and metering method of the lens are adjusted via two potentiometers to be found on the side of the lens. (see ALC/LEVEL)

Zoom lens

Zoom lenses allow the user to infinitely modify the focal length throughout the lens's chosen range. Zoom Lenses generally have much greater focal length ranges than Vari Focal lenses. Zoom lenses maintain focus whilst zooming as long as their have been correctly back focused on the camera.

The zoom lenses are often equipped with motors to change the focal length, focus and even aperture. For automatic positioning systems, there are zoom lenses which are additionally equipped with feedback potentiometers.

Depending on the type of telemetry used, our zoom lenses are available in different types (e. g. H20ZAME-5P (WX))

Type 1	=	DC 6V / separate common	Type 2	=	DC 12V / shared common
Type 3	=	DC 6V / shared common	Type 5	=	DC 12V / separate common

As standard our Zoom lenses are delivered as type 5, any other types are available on request.

Manual zoom lens
e. g. C60812

Motorised zoom lens
e. g. C61237WX