

Technical Note: CAMERA LENS TERMINOLOGY



FOCAL LENGTH

The focal length of a lens is measured in mm and directly relates to the Angle of View that will be achieved. Short focal lengths provide wide angles of view and Lenses nominally greater than 25mm are called telephoto. A "normal" angle of view is similar to what we see with our own eyes, and has a relative focal length equal to the format size of the cameras sensor. Please request our CCTV Lens Selection Calculator pdf document, which is useful for estimating Lens focal length. Alternatively, request a free 'Lens Selection Calculator Disc' (which also includes Angles of View). We can also supply an optical View-Finder (P/N VM300), which indicates focal length.

CAMERA FORMAT

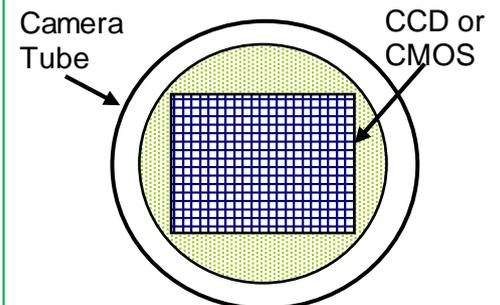
The size of the camera's imaging device (CCD) also affects the Angle of View, with the smaller devices creating narrower angles of view when used on the same lens. The optical format of the lens, however, is irrelevant to the Angle of View, it merely needs to project an image which will cover the device, i.e.: the same format of the camera or larger. This also means that 1/3" cameras can utilize the entire range of lenses from 1/3" to >1", with a 1/3" 8mm lens giving the same angle as a 2/3" 8mm lens. The latter combination also increases resolution and picture quality, as only the centre of the lens is being utilized, where the optics are generally ground more accurately.

COMMON CAMERA IMAGE SENSOR SIZES

In the table below, left; "Format Type" refers to the commonly used type designation for CCD & CMOS etc sensors; the "inch format size is a hangover from the previous era of Vacuum Pick-Up Tube Sensors e.g. Vidicon. These imperial formats do not easily calculate to the actual CCD size – as illustrated in the diagram below, right. "Aspect Ratio" refers to the ratio of Width to Height, "Dia." is the diameter of the tube size (this is simply the Type converted to millimetres) and "Diagonal / Width / Height" are the dimensions of the sensors image producing area.

Format Type	Aspect Ratio	Ø Dia. (mm)	CCD/CMOS Sensor sizes* (mm)		
			Diagonal mm	Width mm	Height mm
1/10"	4:3	2.54	1.60	1.28	0.96
1/8"	4:3	3.175	2.00	1.60	1.20
1/6"	4:3	4.762	3.00	2.40	1.80
1/4"	4:3	7.056	4.500	3.647	2.706
1/3.6"	4:3	7.056	5.000	4.000	3.000
1/3.2"	4:3	7.938	5.680	4.536	3.416
1/3"	4:3	8.467	6.000	4.800	3.600
(1/3")	16:9		6.057	5.28	2.97
1/2.8	16:9		6.259	5.4432	3.0900
(1/2.86)	16:9		6.3	5.346	3.335
1/2.9"			6.3	5.0232	3.7536
1/2.7"	4:3	9.407	6.721	5.371	4.035
1/2.5"	4:3	10.160	7.182	5.760	4.290
1/2.3"	4:3	10.836	7.66	6.17	4.55
1/2"	4:3	12.700	8.000	6.400	4.800
1/1.8"	4:3	14.111	8.923	7.163	5.438
1/1.7"	4:3	14.941	9.500	7.600	5.700
1/1.6"	4:3	15.986	10.07	8.08	6.01
2/3"	4:3	16.933	11.000	8.800	6.600
1/1.2"			13.33	10.67	8.00
1"	4:3	25.400	16.000	12.800	9.600
4/3"	4:3	33.867	22.500	18.000	13.500
1.8"	3:2	45.720	28.400	23.700	15.700
35mm Film	3:2	n/a	43.300	36.000	24.000

Illustration of Sensor Format Types



Comparison looking at face view of a Camera Pick-Up Vacuum Tube Sensor, with a CCD superimposed on the imaging face, to illustrate the correlation of Imperial Optical Format Types.

Note: Typical sizes for camera tubes were: 1/2", 2/3" & 1" diameter.

***Note:** The CCD/CMOS Sensor Format Image sizes are approximate, as there are slight variations between manufacturers!

C and CS LENS MOUNT

Most CCTV Cameras and Lenses are generally CS-Mount. With CS-Mount Cameras, both types of Lenses can be used, but the C-Mount Lens requires a 5mm spacer ring (P/N VM400) to be fitted between the camera and lens - to achieve a focused image. Machine Vision Cameras are usually C-Mount, with a few exceptions being CS-Mount or even the larger F-Mount. It is not possible to use CS-Mount Lenses on C-Mount cameras. The C and CS-Mount Lenses have a common thread size of 1-32UNF (1"x 32TPI). The Back-Focus Distance (distance from the front of the Cameras Sensor/image plane to the end of the Lens Mount) is 17.525mm for C-Mount and 12.5mm for CS-Mount. Some Cameras have a Lens Mount which can be mechanically adjusted to fine tune the Back-Focus Distance. This feature is useful for Fixed-Focus (usually Wide-Angle) Lenses and Zoom Lenses – where the correct exact Back-Focus is essential, to keep par-focus throughout the zoom range.

F MOUNT

Machine Vision Cameras, with larger format sensors (usually bigger than 1"), particularly Line-Scan Cameras, require a larger format Lens than the 1" C-Mount. These cameras generally use the standard Nikon photographic camera bayonet F-Mount. We can supply a variety of F-Mount Lenses as well as C-F Adaptors.

M12 Mount (S or D-Mount) and M13, M9, M10 Mount

Most compact and Board (PCB) Cameras with smaller sensors (1/3" & 1/4"), usually have an optional M12 Mount. This uses the common 12mm diameter x 0.5mm pitch thread Mini Board Lenses; which are sometimes referred to as S or D-Mount (not to be confused with the larger D-Mount Cinema-Photography Lenses).

There are also non-standard M12 x 0.75mm Lens Mounts in use (some Sentech Cameras).

The M13-Mount Lens is less common, having a 13mm diameter x 1mm pitch thread (Panasonic & Watec).

These lower cost compact Board Lenses offer comparable quality to the more expensive Larger Format (C & F Mount etc). They are not usually fitted with an iris diaphragm or focus mechanism. (The usual method to obtain sharp focus is to physically screw the lens in or out of its camera mount). These Lenses are generally 1/4", 1/3", 1/2" or 2/3" format and thus only suitable for cameras with 2/3" or smaller sensors.

It is also possible to use the M12 or M13-Mount Lenses on most C or CS-Mount Cameras, by using a suitable adaptor. As the cameras become smaller, there are also other Mounts/Lenses used e.g. M10, M9 etc.

F-STOP

The lens usually has two measurements of F-Stop or Aperture, the maximum Aperture (minimum F-Stop) when the lens iris diaphragm is fully open, and the minimum aperture (maximum F-Stop) just before the iris completely closes. The F-Stop has a number of effects upon the final image. A low minimum F-Stop will mean the lens can pass more light in dark conditions (often called a Fast Lens), allowing the camera to produce a better image at night. A maximum F-Stop may be necessary where there is a very high level of light or reflection, as this will prevent the camera from "whiting out" or over exposing, and thereby help maintain a constant video level. Some Auto-Iris (AI) Lenses are supplied with Neutral Density spot filters, to increase the maximum F-Stop. The F-Stop also directly affects the Depth of Field (as explained below).

DEPTH OF FIELD (DoF)

The Depth of Field or Depth of Focus refers to the area within the field of view which is in focus. A large depth of field means that a large percentage of the field of view is in focus, from objects close to the lens often to infinity. A shallow depth of field has only a small section of the field of view in focus. The depth of field is influenced by several factors i.e. a wide angle lens generally has a larger depth of field than a telephoto lens, and a higher F-Stop (aperture) setting typically has a larger Depth of Field than a lower setting. Also, when using AI (Auto-Iris) lenses, the automatic adjustment of the aperture also means constant variation of Depth of Field. In addition, the size of the cameras pixels (CCD or CMOS sensor) can also affect the DoF. The small Depth of Field is usually most apparent at night when the lens iris diaphragm is fully open and the depth of field is at its minimum. Objects that were in focus during the day may become out of focus at night – due to variations in the light wavelength, particularly if Infra-Red light is present.

AUTO (AI) or MANUAL IRIS (MI)

Generally we tend to use auto iris lenses externally where there are variations in the lighting levels. Manual iris lenses are used normally for internal applications where the light level remains constant. However, with the introduction of electronic iris cameras it is now possible to use manual iris lenses in varying light conditions and the camera will electronically compensate the shutter speeds. There are several considerations to this option though: the setting of the F-Stop becomes critical; if the iris is opened fully to allow the camera to work at night, the Depth of Field or Focus (DOF) will be very small and it may be more difficult to achieve sharp focus even during the day. The camera can maintain normal video levels, but it cannot affect the depth of field. If the iris is closed to increase the Depth of Field, the low light sensitivity performance of the camera will be reduced.

VIDEO DRIVE (VD) or DIRECT DRIVE (DD)

With Auto-Iris Lenses it is necessary to control the operation of the iris to maintain perfect picture levels. Video driven lenses contain amplifier circuitry to convert the video signal from the camera into iris motor control. With Direct Drive Lenses, the camera must contain the amplifier circuitry, and the lens now only contains the galvanometric iris motor (making it less expensive). The deciding factor depends on the auto iris output of the camera. Most now have both types, except Machine Vision Cameras, which generally do not have any drives.

VARIFOCAL LENS

A Varifocal Lens has a user adjustable focal length range, which will require re-focusing each time the magnification is changed. This type of Lens is usually more compact and much cheaper than a traditional Zoom Lens (which typically remains in focus (parfocal) throughout the zoom range).