

M12 Lenses

White Paper

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1.0 Introduction

This document aims to provide you with information about M12 lenses to help you make an informed decision about your purchase.

1.1 What is an M12 lens?

An [M12 lens](#) is a small lens that usually attaches to a board camera. They lack any adjustment of the iris and are focused by screwing them closer or further into their mount to vary the distance from the sensor. They come in many different focal lengths ranging from fisheye and wide angle to macro and telephoto.



2.0 Background

These lenses have an official name of S-Mount lenses but are usually called M12 lenses due to it being descriptive of the size of their mount.

2.1 Why is it called an S mount or M12?

The name M12 lens comes from the size of the mount that is used on these lenses. They use an M12 x 0.5mm thread to attach to the camera.

In the term S-Mount the letter “S” stands for short and was designated because it has the shortest distance between the lens and the sensor of all lens mounts. Some M12 lenses can focus at distances of <1mm as opposed to 12.52mm for a [CS-Mount](#) and 17.526mm for a [C-Mount](#).

2.2 What does the f-number mean?

In simple terms the f-number or f-stop of a lens represents the size of the aperture and therefore how much light can enter the lens. M12 lenses usually have a fixed aperture and therefore a constant f-number. A smaller f-number means a larger aperture and more light can reach the sensor. The main practical use for a larger f-number is to increase the depth of field which enables a larger portion of the image to be in focus.

The f-number is actually the ratio between the focal length and the effective aperture of the lens. This is calculated by dividing the focal length by the raw aperture size.

The standard f-numbers used on most lenses are f1.4, f2.0, f2.8, f4.0, f5.6 and f8.0. When the f-number increases by one the light entering is halved. Scorpion Vision stocks M12 lenses with f-numbers ranging from [f1.4](#) to [f8.0](#) for use in various situations.

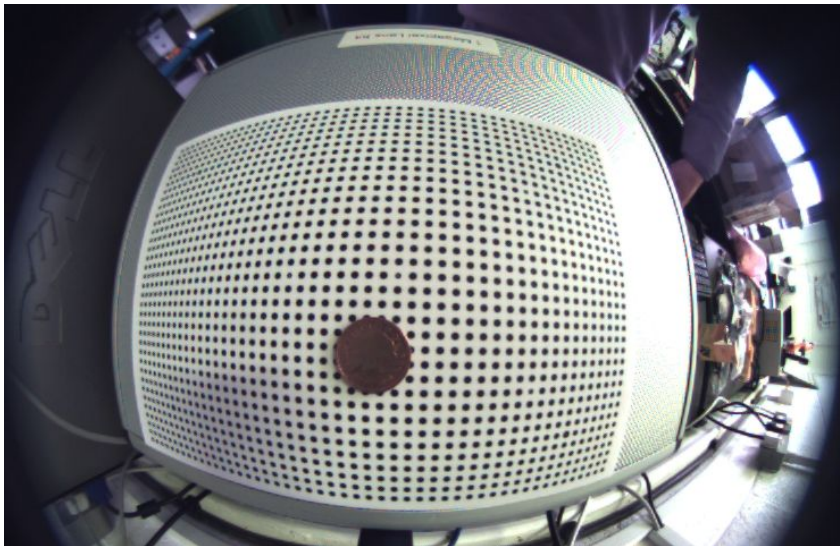


3.0 Characteristics of Different Focal Lengths

M12 lenses are available with a variety of different focal lengths. These range from [1.08mm fish-eye](#) lenses to [50mm far field](#) lenses with many medium focal lengths in between. The different focal lengths produce image with varying characteristics such as field of view and distortion.

3.1 Example: 1.3mm Fish-eye Lens

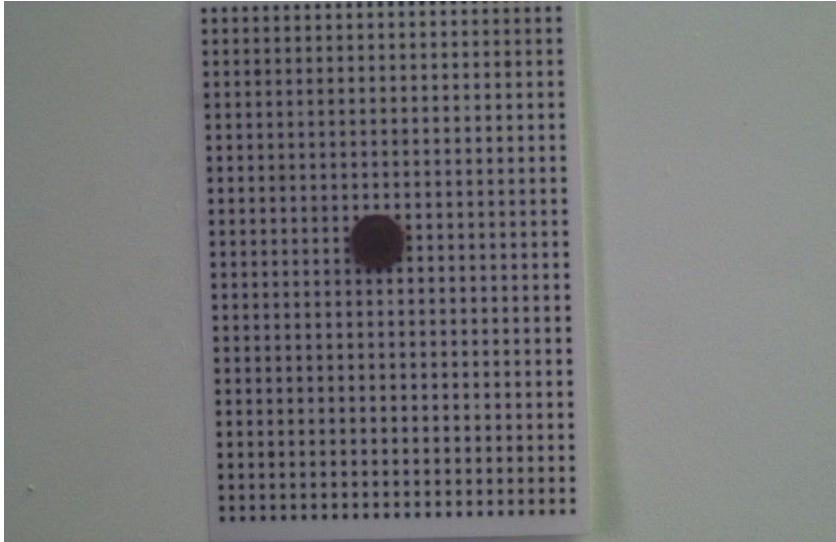
Below is a sample image taken with a [1.3mm fish-eye](#) lens and a 1/3" Aptina MT9V024 sensor. In this image the penny (d=20.3mm) was at a distance of 8cm from the lens.



The purpose of a fish-eye lens is to capture as much as possible in the image and this lens has a super short focal length which provides a huge field of view (195°). However this does create distortion in the image meaning it cannot accurately be used to gauge object sizes. Due to this being a 1/2.3" format lens on a 1/3" sensor the lens casing itself can be seen at the edges of the image. Despite these things this lens produces an excellent quality image with the penny being sharp.

3.2 Example: 50mm Far Field Lens

Below is a sample image taken with the [50mm far field](#) lens and a 1/3" Aptina MT9V024 sensor. In this image the penny (d=20.3mm) was at a distance of 330cm from the lens.



This lens has a super large focal length which enables it to produce a close image of far objects. Compared to the fish-eye this lens has a much more limited field of view (10°) which means that distortion is kept to a minimum. This focal length means that producing a sharp image requires the lens and camera to be kept very steady. This type of lens is ideally suited to non-contact measurement applications due to the very low level of distortion.

3.3 Example: 6mm Macro Lens

Below is a sample image taken with a [6mm macro](#) lens and a 1/3" Aptina MT9V024 sensor. In this image the penny (d=20.3mm) was at a distance of 8cm from the lens.



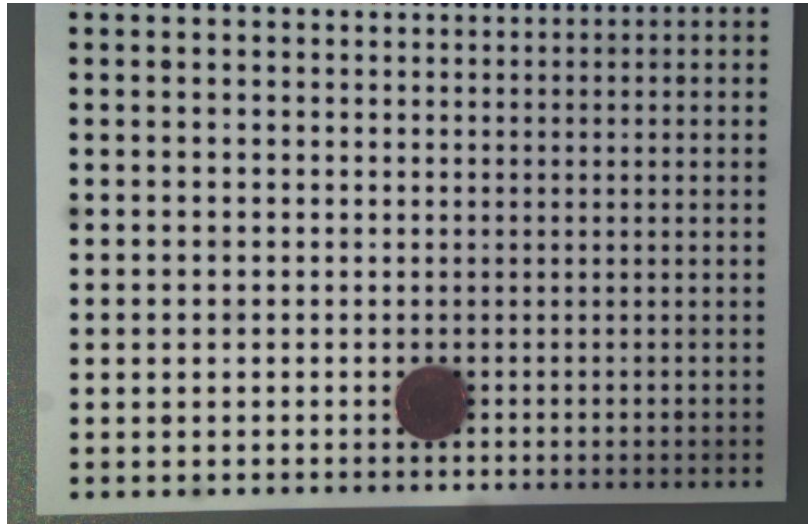
This lens has a medium focal length and has macro functionality. This means it can be used to capture a close up image of an object. The image produced is very sharp and has low distortion.

3.4 Example: 4.1mm Telecentric Lens

Usually as the focal length decreases the distortion is increased. The exceptions to this are telecentric lenses. Telecentric lenses have reduced field of vision and smaller aperture to minimise distortion of the image.



Below is a sample image taken with a [4.1mm telecentric](#) lens and a 1/3" Aptina MT9V024 sensor. In this image the penny (d=20.3mm) was at a distance of 20cm from the lens.



Being telecentric, this lens has a reduced field of view (86.4°) compared to other lenses with similar short focal lengths. This means the image has minimal distortion and so is useful for accurately obtaining the size of objects.

Note the sides of the grid which appear to be very straight, in direct comparison to images taken with a wide angle lens.

4.0 M12 Lens - Sensor Compatibility

Optical requirements aside, there are two main considerations to think about when selecting an M12 lens, the sensor size and the rated megapixel compatibility.

The former is a critical function because if the sensor is listed as 2/3", yet the lens is quoted as a 1/4" sensor, the image will be cropped where the aperture of the lens is too narrow for the sensor. So the lens aperture size should always be equal to, or exceed the size of the sensor.

Megapixel rating is more relevant now, with the crop of higher quality M12 lenses because the lenses can be rated up to 12MP. However, a 1MP rated lens will work with a 10MP sensor but the megapixel rating should be as close to the sensor resolution as possible.

5.0 M12 versus C-Mount Lenses

5.1 What are the main differences?

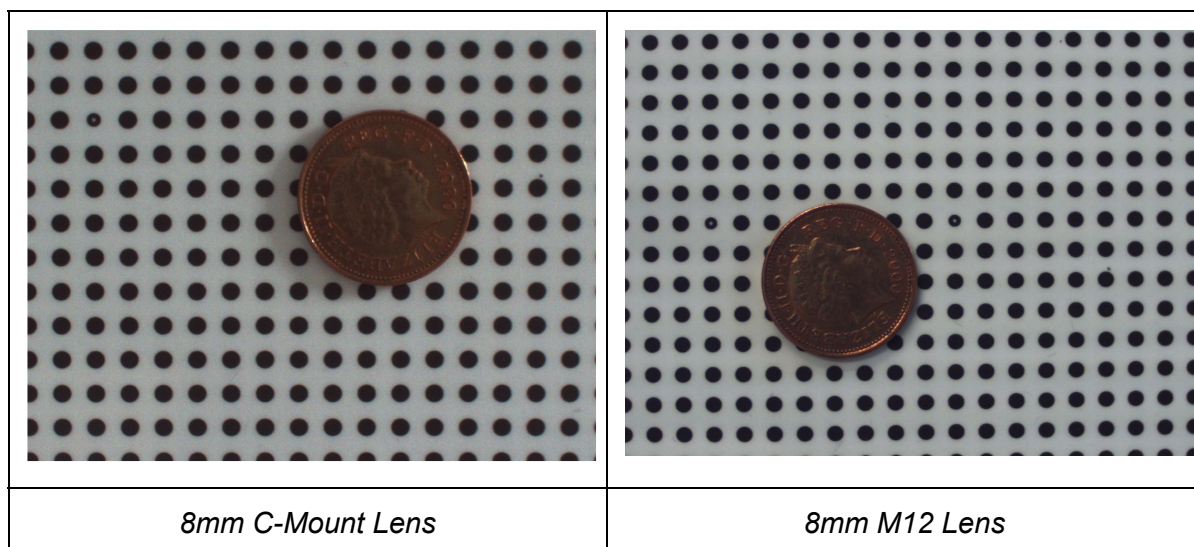
- A C-mount lens usually has an adjustable iris whereas the M12 does not.
- An M12 lenses is focussed using the screw thread as opposed to a C-mount lens which uses a focussing ring.
- An M12 lens contains less glass than a C-mount lens.

- All of this means that M12 lenses are much smaller and lighter and are generally cheaper than C-mount lenses.
- C-mount lenses with very short focal lengths (especially fish-eye) are quite rare and very expensive compared to their M12 equivalents.

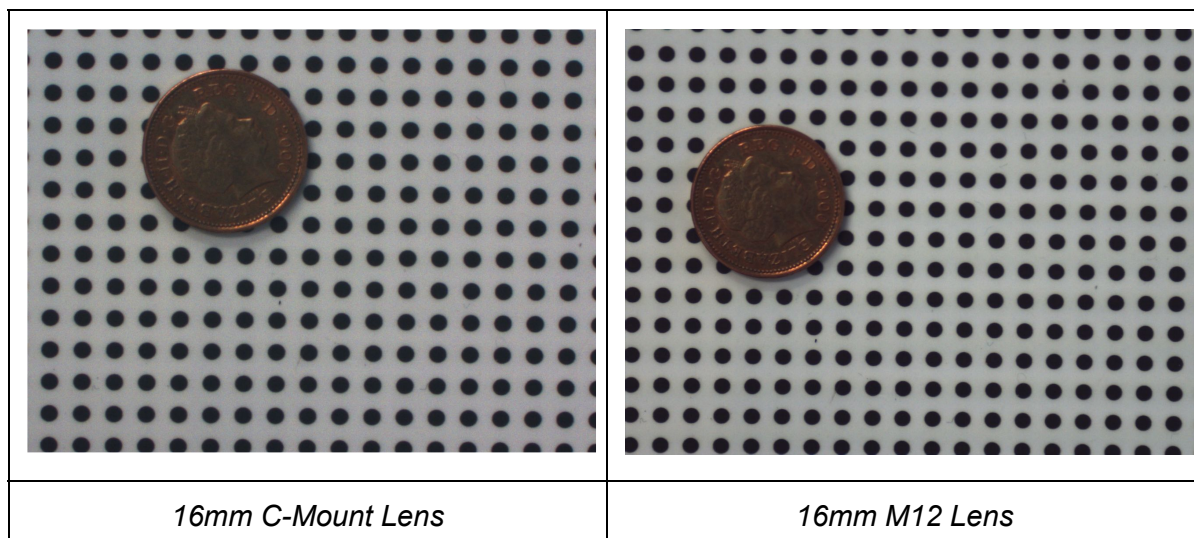
5.2 Image comparison examples

To compare the difference in image quality between M12 and C-mount lenses we used the same [camera](#) (1/2.5" Aptina MT9P031 sensor) to capture an image using two lenses of the same focal length but different mounts.

Below are two sample images taken with an [8mm C-mount](#) and an [8mm M12](#) lens respectively. In these images the penny (d=20.3mm) was at a distance of 20cm from the sensor.



Below are two sample images taken with a [16mm C-mount](#) and a [16mm M12](#) lens respectively. In these image the penny (d=20.3mm) was at a distance of 45cm from the sensor.





These four images show that the difference in image quality between standard C-mount lenses and Scorpion Vision's M12 lenses appears almost negligible. All four lenses produced sharp images of the penny although this was quicker to obtain using the C-mount lenses due to their focussing rings. The M12 lenses do seem to be slightly brighter and offer better contrast between the black dots and white background. This is probably because more light is able to reach the sensor due to less glass and shorter lens depth.

6.0 Limitations of M12 Lenses

Although M12 lenses have many advantages over C-mount lenses such as size and cost there are also some disadvantages.

- M12 lenses contain less glass than C-mount lenses. This makes them lighter but the image is less refined.
- Due to their small size M12 lenses are limited to smaller apertures. C-mount lenses can have larger apertures meaning more light reaching the sensor and therefore better images. The largest aperture M12 lens stocked by Scorpion Vision is [f1.4](#) with the majority being smaller whereas C-mount can offer [f1.2](#) or even [f1.0](#).
- M12 lenses have fixed irises meaning that it is not possible to increase light entering the lens.
- M12 lenses are limited to the size of sensor they can be used with. We have not seen an M12 lens compatible with a 1" sensor for example.
- M12 lenses do not have filter threads on them.

7.0 Using Optical Filters with M12 Lenses

Most M12 lenses are available with a special coating that blocks light from ~ 800nm wavelength band upwards. This removes infra red from the image and can have a stabilising effect on colour images, improving colour balance. However, infrared detection is also a useful tool for night vision or where the subject is only illuminated with an infrared light source. So infrared filters are available as an option in many cases, though the default is usually with the IR block as standard.

In machine vision, it is often a requirement to block or pass certain optical wavelengths. With C-mount lenses, this is easily addressed by using the filter thread that is usually located at the front of the lens. There are [numerous filters](#) available for C-mount lenses which screw into the front of the lens.

Adding a filter retrospectively to an M12 lens is more difficult because there is no filter thread and no room to add a filter thread. However, slip-on filters are available for M12 lenses which simply fit onto the front of the lens. These are usually made to order as they have to



be manufactured with the diameter to match the lens. For these reasons, they are not as readily available.

8.0 Why M12 Lenses from Scorpionvision.co.uk?

Since its inception in 2006, we have sold 1000's of M12 lenses from our ecommerce web site. In the early days a decade ago, the lenses were sold with [low cost board cameras](#). The main point being that the package of lens, lens base and camera was a low cost solution suitable for certain applications where higher resolution or image quality wasn't such a concern.

The sensors used were typically no bigger than 1/3", and in most cases 1/4", with pixel counts of less than 1000,000 (usually below one megapixel). The M12 lenses therefore met a certain criteria and the required specification was no more demanding than this.

We have seen the sensor evolve dramatically in this time. M12 lenses have not kept up and it has been very difficult to source a complete optical range from one place. This has been our frustration. So we have been working on our own M12 product list and have built a portfolio that offers just about any optical M12 lens solution. In addition, we have control over the source so we can guarantee reliability of supply.

Note: An M12 Lens can be used in a C-Mount with the use of an [M12 to C-Mount adapter](#).

8.1 I can buy an M12 lens from Amazon for less than 5 dollars!

Yes you can, you can buy most focal lengths for a very low price. These lenses are low cost by virtue of mass production. They are usually manufactured with plastic barrels and plastic lenses. Image quality is OK and they are probably good for general use. However, the f-number and optical focal length cannot be guaranteed as these lenses are not manufactured to strict, benchmarked standards. Additionally, there is no guarantee of continued production as at the end of the production run, they may not be manufactured again with the same specification, if at all.

A good quality M12 lens is manufactured with an alloy barrel and ground glass. In addition, a good quality lens usually has its optical properties printed on the side of the rim. Purchasing a quality lens from a reliable source is a better guarantee of continued availability with a specification that will not change.

9.0 Practical Uses and Case Studies

There are two obvious areas where growth of the M12 lens market has been driven by consumer take up of certain technologies. In addition, the increasing quality of M12 lenses and the ability of software algorithms to compensate for any shortfall in image reproduction means that M12 lenses are being increasingly used in machine vision applications.



9.1 The Sports Action Camera

GoPro, widely considered to be the original market leader, launched their first action camera using an [M12 lens](#), the [GoPro Digital Hero](#) in 2006. Prior to the launch of that particular product, GoPro's first devices used 35mm film in a similar way to the disposable cameras of the time which used a cardboard body and a very low cost, plastic lens.

9.2 Airborne Drones

In parallel to the evolution of the sports action camera is the advent of the airborne drone. Applications are diverse, covering land and property survey, wildlife filming, security, military and of course the hobbyist. The evolution of the imaging sensor with higher quality M12 lenses means that miniaturisation does not come at the cost of quality. Quite the opposite in fact. The reader only has to watch the latest crop of wildlife programs produced by the BBC to see the fantastic quality of filming that is being done by these small airborne machines, equipped with the latest miniaturised camera technology, no doubt filmed through the increasingly ubiquitous M12 lens.



*Image taken from [Planet Earth II - Behind the Scenes](#)
(follow the link to see the trailer, some footage of which can only have been taken using
drones).*

9.3 Stereo Vision for Robots

A new breed of industrialised cameras equipped with M12 lenses, used for quality control, optical sorting, measurement and robot vision are becoming more commonplace within the industrial automation sector.

A prime example of this is the new [Scorpion 3D Venom Camera](#). Designed by the Norwegian company Tordivel AS, this new - very small - industrial camera uses innovative optical technology based on M12 lenses.

The camera creates two images with a short baseline between the sensors that is used to create a stereo image using software. This camera is used to very accurately measure depth



using the stereo configuration. The 3D machine vision algorithms in the accompanying Scorpion Vision Software can create 3D point clouds, height maps and 3D models from the two images generated from this camera.

A key component is the very special M12 lenses designed by Tordivel, which have a high f-stop, giving superb depth of field. A very important factor in this kind of non contact measurement application. Any optical distortion which can be a drawback with such small lenses is corrected by the software, so negating any potential shortfalls with this configuration.

9.4 Autonomous Vehicles

Mentioned here simply because Autonomous Vehicles are the future that is already here. It could be argued this should come under the Drone heading as the applications are very similar in terms of navigation and monitoring.

M12 lenses are being used on the new generation of vehicles that will be defined by their ability to navigate and drive themselves partly due to the array of onboard cameras that are critical components in a self driving or autonomous vehicle.

10.0 Summary

M12 lenses have been around for a long time but applications have been very specialist, typically in the security sector or in the scientific or machine vision sectors, where M12 lenses have had their uses where space limitations are a consideration.

Always considered inferior to their much larger, heavier and more expensive C-Mount siblings, M12 lenses have been a poor relation.

With the evolution of robotic vision, the mass uptake of sports action cameras and of course the incredibly versatile drone, the demand for M12 lenses has increased 100 fold, as has the quality.

It is feasible that M12 lenses can take the place of more expensive lenses, a fact that may not have been considered just a few years ago.

If you notice an error in this document, or would like to see more detail in a specific section, please email support@scorpionvision.co.uk. Any feedback will be gratefully accepted.