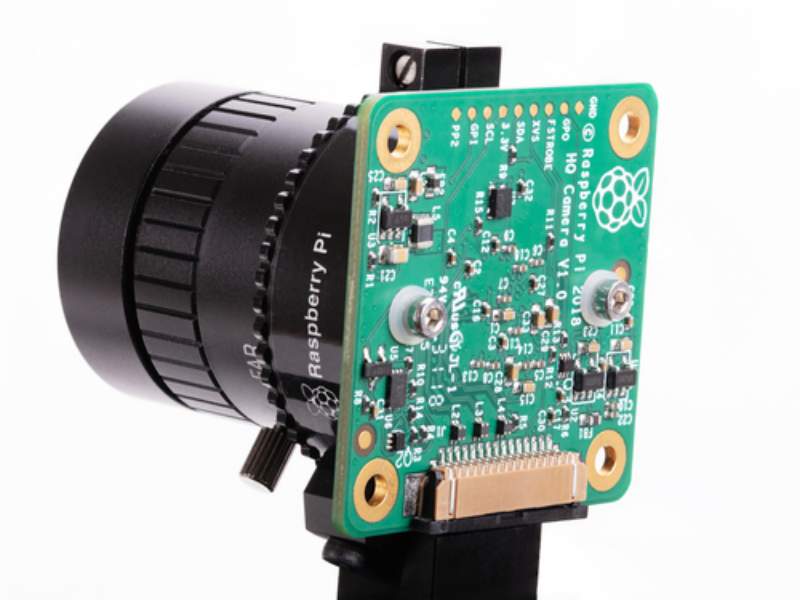
adafruit learning system

All About Raspberry Pi HQ Camera Lenses

Created by Dylan Herrada



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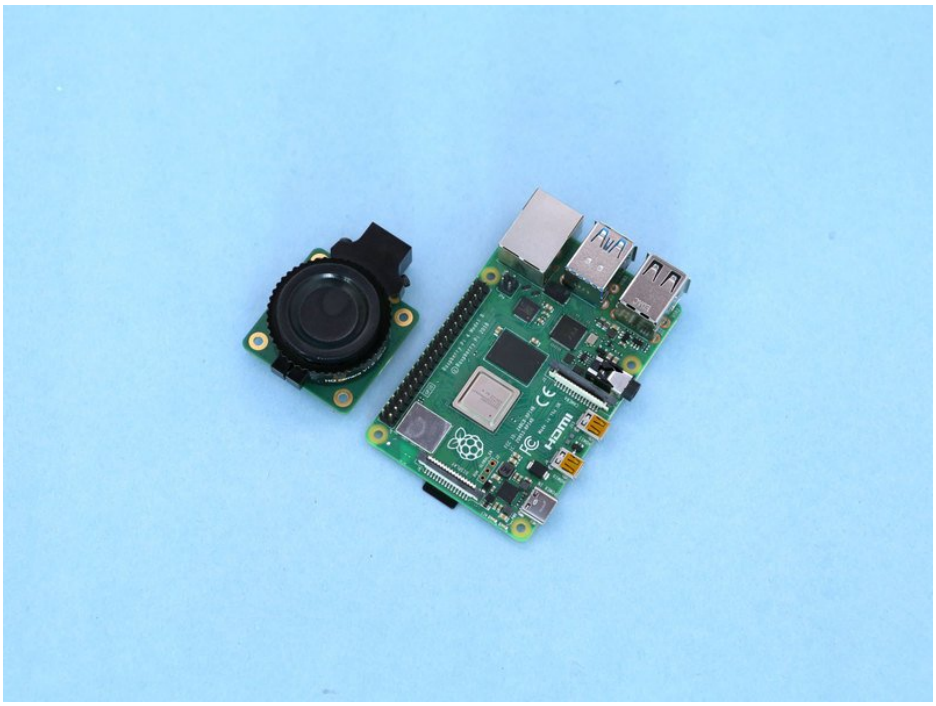
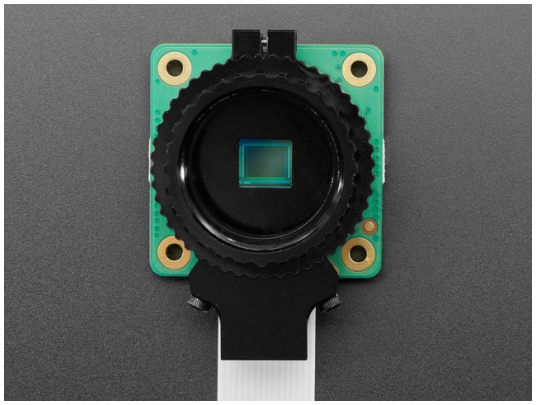
Overview



In this guide, I'll explain the 3 main lens options for a Raspberry Pi HQ Camera. I do have a few years of experience as a video engineer and I also have a decent amount of experience using cameras with relatively small sensors (mainly mirrorless cinema cameras like the BMPCC) so I am very aware of a lot of the advantages and challenges associated. That being said, I am by no means an expert, so apologies in advance if I get anything wrong.

Parts Discussed



Raspberry Pi High Quality HQ Camera

$50.00
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16mm 10MP Telephoto Lens for Raspberry Pi HQ Camera

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6mm 3MP Wide Angle Lens for Raspberry Pi HQ Camera

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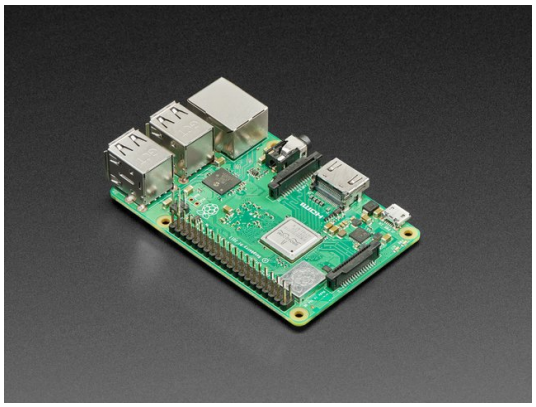

Raspberry Pi 3 - Model B+ - 1.4GHz Cortex-A53 with 1GB RAM

$35.00

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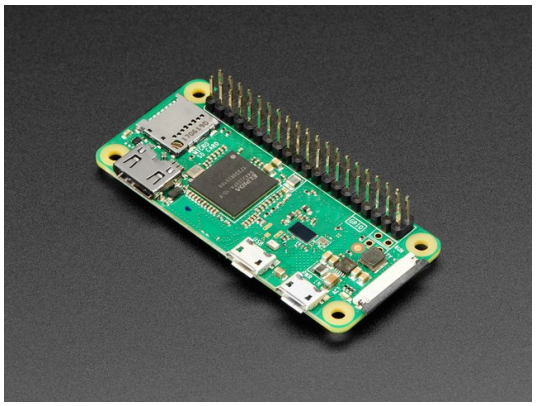

Raspberry Pi Zero WH (Zero W with Headers)

$14.00

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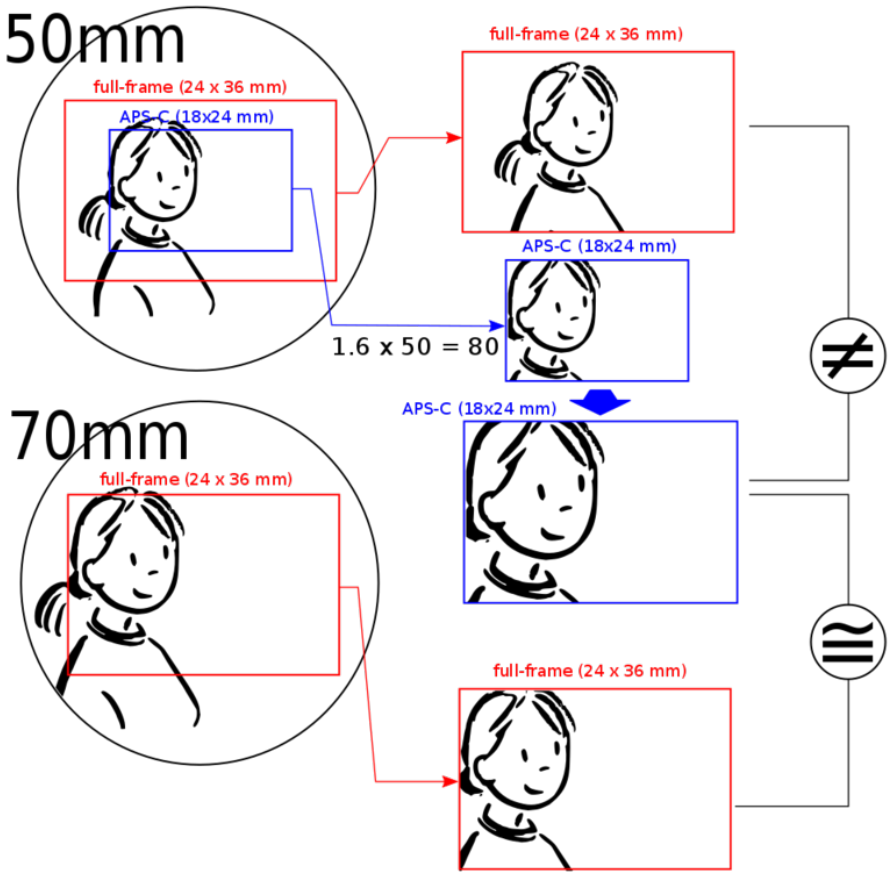
Crop Factor

What is crop factor?

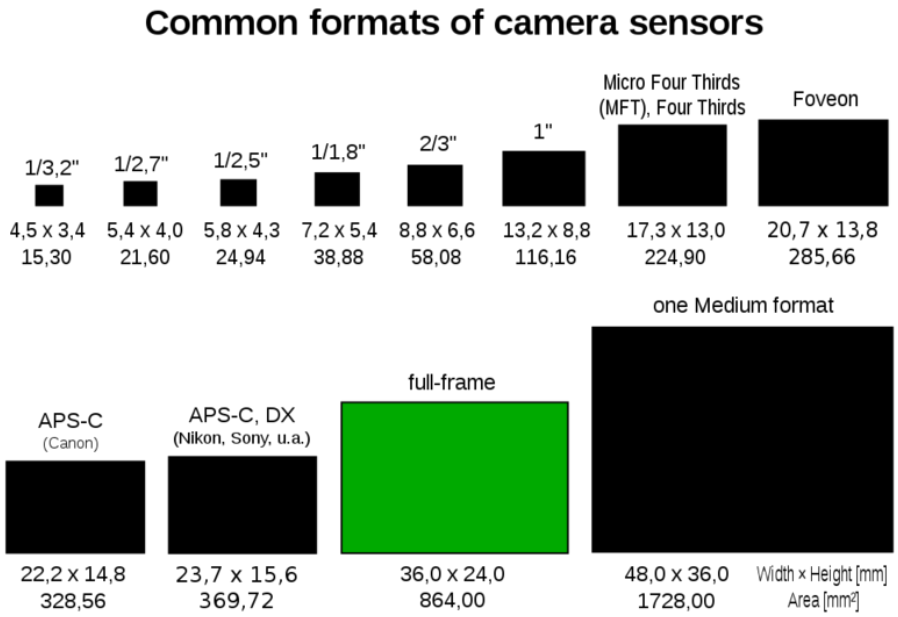
According to Wikipedia (https://adafru.it/MF0):

> In digital photography, the crop factor, format factor, or focal length multiplier of an image sensor format is the ratio of the dimensions of a camera's imaging area compared to a reference format; most often, this term is applied to digital cameras, relative to 35 mm film format as a reference.



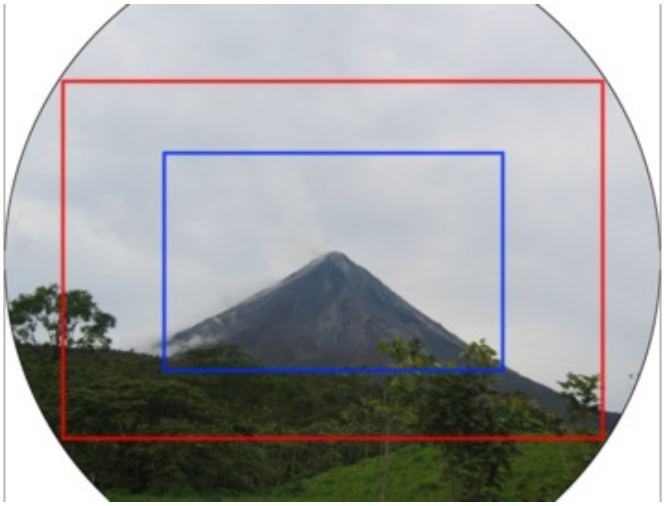
How is it calculated?

The crop factor of a camera is determined by dividing its diagonal dimension by the diagonal dimension of a 'full-frame' sensor, 43.3mm. For example, the Raspberry Pi HQ camera has a sensor size of 6.287mm x 4.712mm. Using the Pythagorean theorem, we can determine that the diagonal size of this sensor is 7.85mm. Now, taking 43.3mm and dividing it by the number we just found, 7.85mm, we get a crop factor of 5.5x.



Practical implications

So, what does all this mean? Well, because the focal length for just about any lens uses a 43.3mm diagonal sensor as a reference point, a much smaller sensor with the same lens only capturing the center of the image would make the image appear much more zoomed in. The image below compares full-frame sensors with APS-C sensors. As you can see, the smaller APS-C sensor will have a narrower field of view and will appear more zoomed in.



Practical implications

So, what does all this mean? Well, because the focal length (the field of view, sometimes just referred to as the zoom) uses a 43.3mm diagonal sensor as a reference point, a much smaller sensor with the same lens would only capture the center of the image. The image below compares full-frame sensors with APS-C sensors. As you can see, the smaller APS-C sensor will have a narrower field of view and will appear more zoomed in.

Crop factor and video

Since the CSI (https://adafru.it/MF1) connector in the Raspberry Pi transfer the Bayer data from every single one of the 12.7 million pixels on the Pi sensor 30 times a second, `raspivid` and `raspividyuv` both take the center 1920x1080. This effectively crops the image, and for the Pi HQ camera, this is an especially large issue. **When shooting a video, the Pi HQ Camera uses around 3mmx1.7mm of the sensor, giving it a crop factor of 12.5x.** This isn't really an issue with the other Raspberry Pi cameras, as they have very wide-angle lenses to counteract this, but with the HQ camera, this can be very problematic.

Here are 3 images. The first was taken with a full-frame camera at 50mm.

The second has a 5.5x crop applied in editing, giving it a focal length of 275mm. This is the same crop factor the Raspberry Pi HQ camera has at full resolution when taking a photo.

The third image has a 12.5x crop applied, which is the crop factor you'd experience when taking a video. The focal length is effectively 625mm.

Lens Adapters

Going this route might make the most sense if you already own a DSLR or DSLM (mirrorless) and want to use your lenses from that. Assuming you already have those lenses, this will be the cheapest option of the three discussed in this guide.

There aren't very many lens adapters that let you put a lens from an interchangeable-lens camera on a C or CS-mount body, so you may not be able to find one that fits your lens mount.

One thing to consider when using lenses intended for APS-C or full-frame cameras on a sensor as small as the one on the Pi HQ camera is the crop factor. As discussed previously, the Raspberry Pi HQ Camera has a crop factor of 5.5. This means that if you were to use a 50mm prime lens, the effective focal length would be 275mm, turning a lens that would be a neutral lens on a full-frame camera into a telephoto.

Another thing to consider is weight; having a lens that weighs 10X what the rest of the camera weighs can be a bit unwieldy at times. For heavier lenses, you need to make sure the weight of the lens is going to the 1/4" 20 tripod adapter on the base of the camera and not the PCB itself.

Make sure that either your lens or the lens adapter has an aperture adjustment ring. The one I purchased (https://adafru.it/Ob2) did not, and I only own one F-mount lens with a manual aperture ring.

Vintage C-mount Cinema Lenses

Vintage C-mount cinema (often shortened to cine) lenses are an excellent option if you want the best quality you can get and are okay with spending a little bit more. Decent ones start around $50, about the price of a higher-end new CCTV lens or a really nice used one by a more well-known company, and nicer ones can go for hundreds of dollars depending on the make and condition of the lens.

Owners of some mirrorless cinema cameras (also plagued by the same issues caused by a small sensor size) will sometimes use these lenses as they're really good for the price and often come in shorter focal lengths since they were designed for cameras that used much smaller film. They're also pretty light, so you won't get such a front-heavy camera like you'd get using a lens from a DSLR or DSLM.

One thing to keep in mind is that since they are used, and a few decades old, C-mount cine lenses may be damaged or have fungi. Most sellers are pretty honest about this in my experience, but just keep an eye out and definitely don't purchase something if the seller doesn't show the actual glass of the lens.

Also, keep in mind that not all of them have focusing rings. Almost all of these lenses are prime lenses, meaning they have a fixed focal length. If you find a lens with 2 rings on it, one for focusing and one for adjusting the aperture, then it will probably work well with the Pi HQ camera.

Some vintage C-mount lenses measure the focal length in customary units. This is contrary to how most other lenses are measured, and I was slightly confused by this at first. To get the focal length in millimeters, my understanding is that you just have to multiply the focal length in inches by 25.4.

CCTV Lenses

CCTV lenses are usually C-mount, often have very short focal lengths, and are also very cheap compared to a lens from a DSLR or mirrorless camera. You do still have to consider the crop factor, but it isn't as much of an issue because CCTV lenses usually have shorter focal lengths. Most, but not all, CCTV lenses have focusing rings, so keep an eye out for that.

They are really great options, and probably have the best price to performance ratio. However, since they are designed to be used with CCTV cameras which tend to have pretty low-resolution sensors, the glass does not need to be as high-quality as the glass you'd find in a much more expensive lens from an interchangeable-lens camera.

That being said, there are so many other things that affect your image quality that in my personal opinion, it makes the most sense to use a CCTV lens until you actually feel limited by it, and then look into upgrading.

They're probably the best option for most people, but if you're really looking for the absolute best image quality possible, you may want to consider another option. Adafruit carries the following lenses, which are pretty solid and can get great image quality.

16mm 10MP Telephoto Lens for Raspberry Pi HQ Camera

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6mm 3MP Wide Angle Lens for Raspberry Pi HQ Camera

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