Digitizing 35mm Film at Home

There are many ways to convert a 35mm film negative or transparency into a digital image. Which approach is best for you will depend on what you want to do with the images, how much money and effort you want to spend and how many images you want to digitize.

If you only need to digitize a small number of images there are a number of services available. But if your needs are ongoing you will probably find it easier to do the conversions yourself.

Why not just take a digital image of the negative or transparency?

This is what some of the cheaper "scanners" do. They are inexpensive because they use cheap lenses and sensors. They may not provide the resolution you want.

But we don't want the digitization process to become the weakest stage in the process. There is another way to do this and it can provide resolution and quality that is just as good as some of the best scanners by using your own digital camera with a macro lens and a proper light source.

We may want to use a digital camera with more than twice target resolution

The color filter array (CFA) is commonly a Bayer array although Fujifilm use a slightly different X-Trans array. Only about half of the array is covered with green filters and the other half divided evenly between red and blue filters. The resulting values are recombined into a full color image but the process loses about half of the effective resolution (sharpness) in the process. The end result is that a full color camera with a sensor resolution of as much as 48MP can end up with the sharpness of only 24MP.

Sharpness is only one of the many factors that determine the quality of an image. Too much attention is paid to resolution and sharpness since an image may only be truly sharp at the plane of focus.

Digitizing with a macro lens and a good light source

You may already own a good macro lens (Nikon calls them Micro). It is designed to capture a full frame image of a flat subject at a 1:1 ratio. In this case it means capturing a 24x36mm negative or slide on a full frame 24x36mm sensor. But if you are using an APS-C sensor you only need to use a 1:1.5 or 1:1.6 ratio.

Common macro focal lengths are 55mm, 60mm and 105mm. With a macro lens the camera will be very close to the subject. Longer focal lengths are more convenient if you want more distance between the camera and the sunbject.

If you calibrate your monitor you already have a good light source. You only need to position the film far enough from the screen so that the pixels are well out of focus. When you display a white background such as an empty file folder the light will be close enough to photograph color negatives or slides.

This illustration shows a setup using a laptop with an empty directory displayed to provide a white light source. The rectangular frame is the spacer from a shadowbox display and the film is held in place using an enlarger film holder.

The macro lens is left at its 1:1 setting and the film holder or the camera moved to get the film in focus. The difficulty with this setup is in getting the film perpendicular to the lens axis and centered in the frame.

Nikon provides an attachment for their 60mm macro to hold the film or slide to make everything a lot easier.

This helps get the film aligned and focused. The film is mounted in a carrier that can be easily fed through the attachment. It does away with the need for the frame and tripod.

A calibrated LED light source would complete the kit if you don't want to use your computer's display. It will also provide a better range of light for color images.

This LED light is designed to be mounted on a camera but it can be powered by a separate battery or AC adapter and mounted on a tripod. It can be purchased directly from the source with a battery and charger for a little more than the light itself.

Capturing the image of the film

The film should be dusted and mounted in the folder with the emulsion side toward the camera. This will record the image backwards in the camera but that is easily switched in post processing.

To get the best possible result the image should be captured raw at base ISO and exposed to the right to make the best use of the camera's dynamic range.

For slides the highlights will be in the clearer part of the film and the shadows in the denser part. By recording raw it will be possible to do some highlight and deep shadow recovery that might be difficult with scanners whose output is directly to a JPEG or TIFF.

A negative places the shadow information (the clearest part of the negative) at the high end of the exposure. These shadows will be cleaner than could be otherwise achieved with a scanner. The denser part of the negative, where the highlights are found, will end up at the low end of the raw bit values. In film with a normal dynamic range there should be enough latitude to produce nicely toned highlights.

The first step in developing the raw file is to flip the image back to its normal orientation. You then need to switch a negative image to positive, a step that is built in to some raw conversion programs although Capture One needs to use a specific custom style to accomplish this.

If you are working with a color negative you can base the initial white balance on the empty space between frames. You can use the eyedropper on the unexposed area either before or after reversing the image from negative to positive. Once it is set the same white balance can be applied to all of the remaining frames on that roll.

How much resolution you need?

For posting on the internet you don't really need much even if you want the viewer to see the image on a full high definition screen. For example, a 4k high definition monitor needs about 2300-2700ppi (pixels per inch) to display a 24x36mm image. That is a total of less than 9MP. But a typical image on social media it only about 2MP, the same as a 4x6 print.

To make a 12x18 inch print at 300ppi to be viewed from about 18 inches feet you need less than 20MP but the same image can be printed at any size if you are going to view it from a greater distance. If it is printed at 24x36 inches and viewed from about 36 inches it will look the same.

You could scan your film with a flatbed film scanner such as an Epson V600 with an effective resolution (from ScanDig) of 1560ppi (pixels per inch) or one of the larger V700-850 models to get 2300ppi. You could also use a dedicated film scanner and achieve higher a resolution, between 3200 and 4000ppi.

Some scanners may claim higher resolutions but when you scan at the higher values you just get larger files. For example, a V750 with an effective resolution of 2300ppi can be set it to scan at 2400ppi. If you scan at 4800ppi you end up with an image that is four times as large but with the same effective resolution (sharpness).

Is there a limit to how much resolution we can actually use?

Once the resolution is high enough to reveal the film's grain you may not want to go any higher. But even with very fine grained film, the lens used to capture the original image may impose its own upper limit. So does the resolution of the film itself. From a practical viewpoint it, 24MP is a good place to stop, especially with images from older film and lenses.

Digital film image capture compared to film scanning

With the right macro lens and light source you can get a result that is as good as or better than any scanner available today for home use.

Extensive testing was done using two camera bodies (an unmodified Nikon Z7 and a Sony A7 II with the Bayer array removed) and two macro lenses (105mm f/2.8 Lester Dine manual focus macro and a Nikkor 60mm f/2.8 D Micro) and the results were compared to the results from a Nikon Coolscan 9000.

The Coolscan may be the best scanner ever made for home use. Based on testing done by ScanDig it has an optical resolution is 4000ppi. It originally sold for about $1800 but is no longer made. Used models in good condition sell for two or more times the original price.

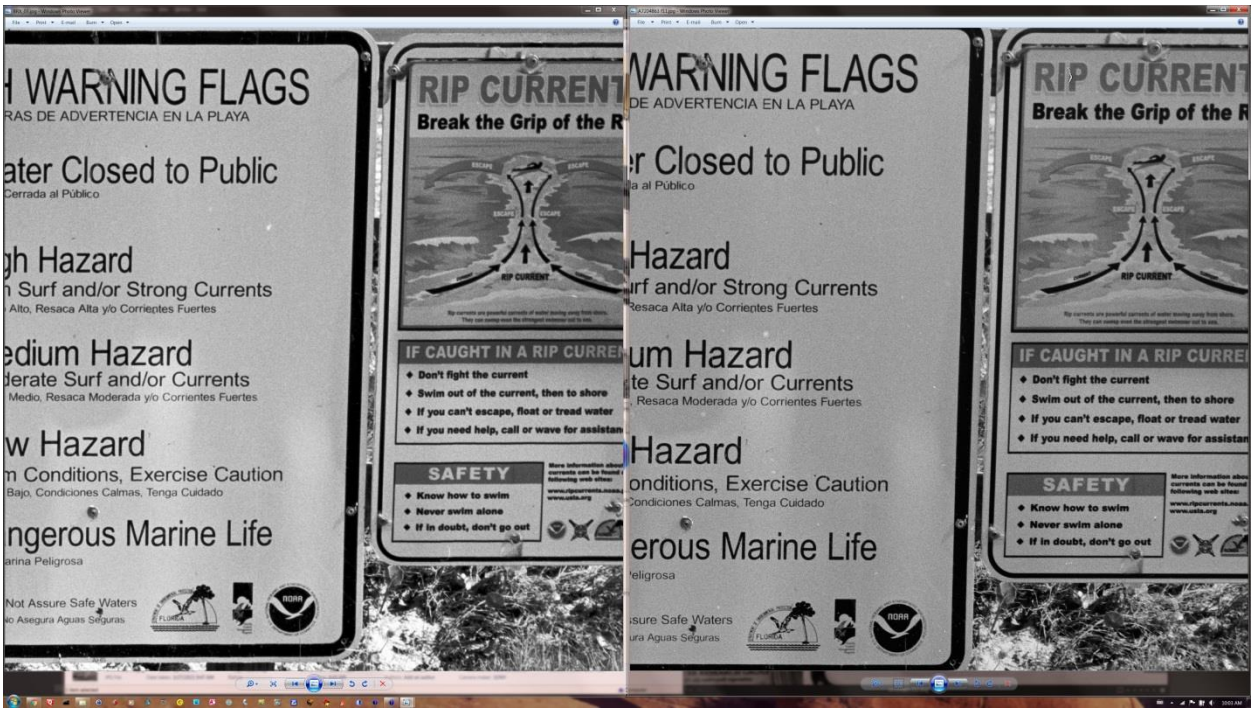
The preliminary tests were intended to compare the resolution of the digital results using medium speed back and white film. The images were saved as raw files and converted using Capture One Pro 21 with minimal processing.

Both macro lenses were used on each camera and all apertures were tested from f/2.8 to f/32 to see where diffraction would begin to degrade the result. The 60mm macro turned out to be slightly better than the 105mm.

From the aperture vs. sharpness test the two cameras reached optimum sharpness at slightly different apertures – f/8 for the Z7 and f/11 for the A7 II. The difference is explained by the presence of the Bayer array in the Z7. Above those apertures diffraction begins to degrade the sharpness of the image.

What is interesting about the apertures is that at a 1:1 magnification there is a loss of two stops of exposure because the aperture is, in effect, twice as far from the sensor. With the lens set to f/8 the effective aperture is f/16. This might lead us to expect diffraction to show up sooner but that assumption is based on theory. It is not supported by the careful testing done here.

The testing also showed that the 24MP A7 II monochrome produced a very slightly higher resolution than the 45.4MP Z7 with the 60mm lens after converting to B&W.



Coolscan vs. A7 II monochrome at f/11

With the 105mm lens the Z7 and A7 II monochrome were indistinguishable.

Here is a 40 year old Kodachrome 25 image.

Kodachrome 24 - Coolscan vs. Z7 with the 60mm lens at f/8

The image on the left is at 100% from the scan and the one on the right is adjusted to about the same size. Both images appear to be equally sharp and the grain is barely apparent in each one. Very little editing was done on the scanned image. There were no color adjustments to the second image but there was some shadow recovery and clarity was increased slightly.

A color negative image requires more effort to get the colors right. Here is an Ektar 100 image.

Ektar 100 - Coolscan vs. Z7 with the 60mm lens at f/8

The sharpness is about equal but the Coolscan got the red stripes wrong (should match the Italian flag).

Conclusion

You can draw your own conclusions from the findings presented here.

It depends on whether you want to occasionally create a digital version of a film image or whether you want to do this for thousands of images. It also makes a big difference if you are working with color images or black and white.

This exercise has helped me decide how to proceed but my objectives may not be the same as yours.