Barninga's DIY macro lens tutorial

A foreword

There is a specific reason why I decided to dive into some DIY and try to assemble a macro lens with a flash ring (sort of), starting from an old, regular, 28-80 mm zoom lens and a bunch of other easy-to-find components: photography accessories are expensive. In the macro photography field things are even worse than usual, due to the relatively small size of the market.

My “old” digital compact camera allows to take interesting closeup shots through its built-in zoom lens, due to the very short focal lengths involved and the small size of the sensor. This is a cool feature a DSLR camera, obviously, can not offer without using specific accessories.

After some searching about macro photography on the Internet, I discovered that a reversed wideangle lens can act as a magnifying lens, thus allowing to take macro shots without using a true, expensive, macro objective. This requires some trickery, however, and this is where this tutorial comes from.

What “macro” means

The word “macro” comes to greek and means “big”: so, a true macro shot is an image that gives a magnified representation of the subject. The ratio between the size of the subject in the photo image and the size of the real subject is called *magnification ratio*. Technically speaking, we have a true macro shot when the magnification ratio is greater than 1, otherwise (ratio ≤ 1) we have a closeup shot.

A simple comparison with a common 35mm frame, which is 36 mm wide by 24 mm high, tells us that we take a true macro shot if the photographed area is no more than 36 mm wide. If it is wider, we have a closeup shot.

It should be noted that many compact digital cameras feature a “macro”, or even a “super macro” shooting mode. Well, that's marketing, just marketing. They are, in most cases, “closeup” modes: for example, the smallest area my compact camera's macro mode allows to focus is 70mm wide, while, in super macro mode, its width decreases to 35 mm. In the first case, the magnification ratio is 0.5 (35 mm / 70 mm = 0.5): we are clearly in the closeup field. Things are better with the so-called super macro mode, where the magnification ratio can be as little as 1, touching the boundaries of real macro shooting.

A reversed lens can go far beyond that boundary.

The lens

As stated above, I used a 28-80 mm zoom lens. The zoom adds some usability, allowing to choose magnification ratio and focus distance (within a certain range: a reverse lens always gives a very shallow depth of field) according to the needs of each single shot. However, the zoom capability is not a requirement: any fixed focal length lens will do.

A more important aspect is that the magnification ratio decreases as the focal length increases: in other words, the shorter the focal length, the higher the magnification. The table on the right compares several focal lengths and the corresponding magnification ratio obtained by using a reversed lens on a camera with a full frame sensor (36 mm x 24 mm).

Focal length	Magnification ratio (full frame sensor)
80 mm	0.25
70 mm	0.40
50 mm	1.00
35 mm	2.00
28 mm	2.75

Table 1: Reversed focal lengths and magnification ratios

As you can see, the boundary between closeup and macro photography is crossed at a reversed 50 mm focal length. Since the sensor of most DSLR cameras is smaller, the image is cropped: as a consequence, the magnification ratio increases by a factor that is a constant for each sensor. Check the features of your camera to calculate the actual magnification ratio, given the focal length of the reversed lens used.

For example, the crop factor of my Canon 30D's sensor is 1.6: this means that the actual magnification ratio for my camera at 28 mm is 4.4 (2.75 x 1.6). Quite good, and even higher than the ratio usually offered by many true macro objectives.

Connecting the lens to the camera

Image 1: Reversing ring and zoom lens.

One cool thing about using reversed lenses is that their bayonet mount does not need to be compatible with the camera: that is, you can bring to new life those old lenses you bought time ago and used with that old camera which lies somewhere now, broken or outdated.

Anyway, Compatible or not, a reversing ring is needed.

A reversing ring is the adaptor which allows to attach the reversed lens to the camera. On one side, it has a male bayonet mount (compatible with the camera); on the other side it provides a male thread which matches with the filter female thread of the lens. Thus, the ring can be screwed on the lens thread (just as if it were a common filter), and then attached to the camera. It is a cheap accessory, which can be usually bought at photography stores, or on specialized Internet sites. Pay attention to the diameter of your lens and to the camera model: these two parameters together define what ring is suitable for you.

If a suitable ring is not available, it can be “composed” by joining two or more rings together: the first one must have a suitable bayonet and a male thread side; the other(s) must have a female and a male thread. For example, I could not find a reversing ring with a Canon FD bayonet mount and a 58 mm male thread to fit into the filter female thread of my lens, so I had to buy two rings:

- Canon FD bayonet to male 52 mm thread
- 52 mm female thread to 58 mm male thread

Except for the increased expense, screwing more rings together is not a problem at all: you'll even get a slightly increased magnification ratio, since it is proportional to the distance between the sensor and the lens (see “Increasing the magnification ratio”, pg. 10).

The drawback of connecting the lens by means of a cheap reversing ring is that you lose any automatic control over the lens, specifically autofocus and aperture. At least with my camera, automatic exposure control still works. This is worth some considerations:

- *Autofocus*. It is not a very important loss. The depth of field is so shallow, that even manual focusing (although still possible) is often uneffective, since the slightest movement of the camera puts the subject out of focus again. The most effective focusing technique is to move the camera back and forth very slowly and carefully, until the interesting portion of the subject is perfectly focused. This means that a tripod is a requirement in order to avoid getting blurred images, even when shooting with fast shutter times. If you can't use a tripod (those damn little insects don't ever want to stay where you put them and sometimes even try to sting!), then set the camera for continuous shooting and always take at least three or four shots by keeping the shutter button pressed: the chance of getting at least one sharp, well focused image increases considerably this way.
- *Aperture*. We can do even without aperture control, since adjusting it causes very little changes to the depth of field: it remains very shallow anyway. With modern lenses, aperture is electronically controlled by the camera: the iris is wide open all the time to allow a more bright view through the viewfinder and closes accordingly to the aperture setting only when you shoot. This means that when you detach the objective from the camera and mount it reversed, its aperture is implicitly set to the minimum f/ value: that is, the iris is wide open and this gives the minimum depth of field. However, there is a workaround. If your camera has a dof-test button (a button that closes the iris accordingly to the aperture setting when you press it, allowing to check the actual depth of field of the image before you shoot), you can set the aperture to the desired value, press the button and, *while still keeping it pressed*, detach the lens. This should block the iris

Image 2: Mold on a tree. Note the very shallow depth of field.

at the desired aperture setting, so that it stay closed when the lens is reversed (don't worry, the iris will reopen as soon as the lens is attached to the camera again). You'll get a darker view through the viewfinder, but you'll work with a slightly less shallow depth of field. Note that many old lenses have an aperture manual control: this simplifies things, as it allows you to vary their aperture shot by shot even while they are mounted reversed.

The problems described above are caused by the fact that the reversing ring interrupts all electronic communication between camera and objective. It must be noted that sophisticated reversing rings do exist, which allow to keep the electronic communication working. They are made actually of two rings: the first one has a male bayonet mount, complete with electronic contacts, on one side and a regular male thread on the other side. It physically attaches the lens to the camera. The second ring has a female bayonet mount, complete with electronic contacts either, suitable for the male bayonet mount of the bottom side of the objective. The two rings are connected by means of a cable set, which transports signals from the bayonet mount of the camera to the bayonet mount of the objective, thus doing the trick.

These reversing rings work very fine, but they also are very expensive. My suggestion is to start with a cheap, simple reversing ring and experiment a little. If you find that this way to macro photography is good for you, there will be time for shelling out the big bucks later anyway...

Light and shadow

A reversed lens focuses at a very short distance from the subject. For example, a 28 mm lens needs to be as near as just a couple of centimeters: it is very likely that the subject happens to be within the shadow of the camera itself. This can be a problem. In fact, due to the shallow depth of field, long exposures increase more than usual the risk of getting blurred images.

The built-in flash of the camera can still be used, but the objective itself will throw its shadow on the subject, leaving it in the dark.

An effective solution is to buy a professional flash ring, consisting of two or more flash lamps mounted around a ring that gets mounted on top of the lens. The lamps are connected to the flash socket of the camera and flash automatically. Very effective, but also very expensive.

An external flash, connected to the flash socket through an extender cable, can also be effective. It is an expensive accessory anyway, and it requires also a flash bracket to attach it to the camera, or to the objective.

Now, since our goal is just to experiment in the macro photography field, we'd better search for an inexpensive and practical solution, though not so “pro”.

A homemade flash ring

Well it's not a flash ring actually, because it doesn't flash. However, it provides a light source on top of the objective, thus solving our problem. At least partially.

Here's what we need to assemble the light source for our experiments:

1. *The bottom-side cap of the objective*. Sad to be said, we'll need to break it (sort of), so maybe you'll want to get a new one to protect the lens from dust when not used.
2. *Some high intensity white LEDs*. LEDs (acronym of Light Emitting Diode) are electronic components that emit light when an electric current passes through them. We'll use white light emitting diodes; in addition, high intensity diodes are preferred, because they emit a much brighter light. More than 20 LEDs can usually fit around the bottom of a 58 mm lens, but we'll begin with just 8. High intensity white LEDs usually work at 4 V (volts), 80 mA (milliampère).
3. Batteries to supply the electric current to the LEDs. We'll use three AAA-size batteries, each supplying a voltage of 1.5 V.
4. A battery container for three AAA-size batteries. It must incorporate the electric contacts and wirings so that the batteries are connected in series, thus giving an output voltage of 4.5 V.
5. A small electric switch.
6. Some electric cable.
7. A jacket clamp for badges.
8. A soldering iron for electronic circuitry
9. Some soldering alloy (common tin and lead alloy is OK).
10. Some strong glue, better if heat-resistant (since we'll have to use the solder on glued components). Sylicon glue will do.
11. A pair of robust scissors.
12. A small saw, suitable to cut thin plastic surfaces.


Image 3: Some of the components needed for this project.

Now that we've gathered the components, materials and tools, we can start assembling the flash ring.

Step 1: make the bayonet mount ring

The first step is to obtain the ring from the lens bottom cap (1). Use the saw (11) to cut out the top of the cap: the goal is to obtain a ring with a female bayonet mount, that can be quickly and


Image 4: Saw the lens cap in order to obtain a ring.

easily attached to the bottom of the objective. It will work as a removable support for the LEDs.

Step 2: glue the LEDs

The next step is to glue the 8 LEDs (2) to the ring, so that they all are equally distant. Using the heat-resistant glue (10), attach the first LED into an arbitrary point of the ring circumference, then glue the second LED into the diametrically opposite point. Then, glue the third LED into a point that is equally distant from the first two LEDs. Now, place the fourth LED so that it is diametrically opposite to the third one. Their light emitting side must (obviously!) be oriented to the opposite of the bayonet mount side of the ring.

That's a simple task. However there is a couple of matters that should be taken into consideration:

Image 5: The LEDs have been glued on the ring, giving them some slant.

- *Slant*. Since the ring is mounted on top of the reversed lens, it will be just few centimeters far from the subject: when gluing the LEDs, slant them a little so that their light converges to the center, where the subject possibly will happen to be, otherwise they will produce a light ring around it. Don't worry about calculating the slant angle, this is not a matter of absolute precision. A little slope will do.
- *Polarity*. LEDs are small, bullet-shaped electronic lamps. Differently from electric lamps, they do have a polarity, which must be respected in order to make them work. So, when gluing the LEDs to the ring, attention should be paid to the position of their leads, so that it will be easier later to wire them the right way. The positive lead is called *anode*, while the negative one is called *cathode*. If you look carefully at a LED, it is easy to distinguish them:
  - (a) The anode (+) lead is usually longer than the cathode (-) lead.
  - (b) The circumference of LEDs is flattened on cathode's side.
  - (c) Inside LEDs, the cathode has the shape of a small flag, while the anode has the shape of an arrow.

  Glue the LEDs on the ring so that they all have the same position, relative to their leads: for example, you could keep keep all the cathodes on the right, looking at the ring from the bayonet mount side. It will be considerably easier to solder the electric wires without confusing polarities.

Image 6: Rear view of the ring. Note that the cathodes of all the LEDs are on the right, looking outside from the center of the ring.

Step 3: wire the LEDs together

Now, the LEDs must be wired. We are connecting them in parallel: all the anodes must be wired together and, in turn, all the cathodes too. It is obvious that anodes and cathodes must not be wired together.

Here is where the soldering alloy (9) and the soldering iron (8) become useful. Soldering the leads of the LEDs is a simple task that, however, requires some care. LEDs are robust electronic components, but an excessive heat can destroy them. In addition, soldering joints must be carefully executed in order to avoid interruptions in the electric line. If you have never handled a soldering iron, it is better that you ask a friend for some help: expert hands will complete the task in a few minutes.

Image 7: Anodes and cathodes must be wired into separate chains.

Use short chunks of electric cable (6).

Step 4: prepare the power source

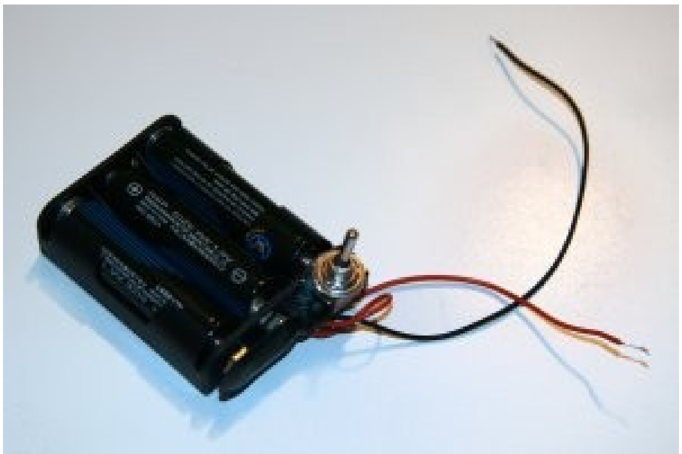

Image 8: Glue the switch to the battery pack and connect the red (+) and gray (-) wires.

In step 3 we've obtained two wiring chains: one for the anodes and one for the cathodes. Now, we prepare the power source to be connected; again, soldering iron, soldering alloy and electric cable are needed. Using a black or gray (negative) and red (positive) coupled cable will make things clearer (and a bit easier).

Glue the electric switch (5) to one side of the battery container (4). Then wire the *positive* lead of the battery container to the center lead of the switch (if the switch has only two leads, any of them will do).

Step 5: a facility

Shooting while holding the battery pack with one hand would not be practical. A simple and effective way to attach it to the camera is offered by those small clamps (7) used to attach office badges to jackets and belts. Just glue it on the back of the battery pack.

Image 9: Glue the clamp to the battery pack.

Step 6: connect the battery pack to the LEDs

Now, using a cable chunk at least a little longer than the full length of the objective, wire one of the side leads of the switch to the *anode chain*. Be careful, if you connect the positive cable to the cathode chain, the LEDs will not work (they will not be destroyed, however).

The *cathode chain* must be connected directly to the *negative* lead of the battery container.

Image 10: That's it!

Quite simple. However, since we are working with electronic components, there are some technical notes that should be taken in consideration with attention. If you don't understand their meaning, ask for further explanation. You have been warned.

We have built a very simplified LED circuitry. According to the books, it is maybe a little oversimplified: a resistor should be connected in series to each LED, to protect them against excessive current flow. Since we supply the power by means of a battery pack, voltage peaks are absolutely unlikely: I think that a single resistor, connected in series to the chain of parallel LEDS, should be adequate. However, I did not use any in this project, because the extra voltage we supply to the LEDs is just 0.5 V: a very low resistance would be needed. In addition, the LEDs are not intended to be working continuously for a long time: more likely they will be on for a couple of minutes or less, while taking a photo, then they will be turned off for some minutes, and so on.

Anyway, your mileage may vary: carefully check the data sheet of the LEDs you purchase for this project (ask the reseller!) and, if possible, also check instrumentally the voltage actually supplied by the batteries you are using: for example, high quality alkaline batteries may supply a little more than 1.5 V and a resistor should be used. However, no resistor would be needed with rechargeable batteries, since they usually supply 1.2 V.

Please carefully read "Appendix I – How to calculate the resistor value" (Pg. 12). I will not be responsible for any loss or damage may eventually arise from following this tutorial.

Step 7: putting it all together

It's time to put all this stuff together.

- Screw the reversing ring into the filter thread of the lens
- Mount the lens, reversed, on the bayonet mount of the camera
- Insert the batteries into the battery container, paying attention to their polarity: usually, battery packs have drawings inside, that show the correct insertion side
- Clamp the battery pack to the neck cord of the camera
- Mount the LED ring on the bayonet mount of the lens

Image 11: Camera, reversed lens, LED ring and battery pack.

Step 8: test it!

Disegno 1: Image 12: It works!

And now... switch it on!

If all the electric connections were made correcly, it will produce a light comparable with the light supplied by a powerful lamp (about 200 candelas). If it does not work, double check the position of the batteries in the battery pack and the wiring, paying particular attention to the anode and cathode chains.

Try photographing several subjects. Try with the LEDs on and off: depending on general light conditions, there should be a difference of several f- or shutter stops (the darker the environment, the bigger the difference).

More Trickery

Increasing the magnification ratio

The magnification ratio of a reversed lens can be increased by positioning it further from the sensor. In particular, the further the lens, the higher the magnification ratio.

As said before, this can be achieved by using professional bellows (which allow a fine setting of the magnification), or a series of reversing rings (see inside “Connecting the lens to the camera”, at pg. 3). It is an expensive solution because, due to the thin size of reversing rings, many of them are required to obtain a significant gain.

An effective alternative, though expensive nonetheless, is represented by step-up rings and tubes. If you like DIY, you can use a cheap epoxy tube (paint its inside black!), firmly glued to the rings: this works even if you mount the lens normally (that is, not reversed) on top of the tube. Hint: Pringles tubes work just fine...

Using two lenses

An interesting trick to achieve stunning magnification rations is to mount a reverse lens in front of a normally mounted telephoto lens. With this kind of setup, the magnification ratio is equal to the ratio between the focal length of the normally mounted lens and the focal length of the reversed length. This means that using, for example, a normally mounted 300 mm lens and a reversed 28 mm lens you get a magnification ratio greater than 10 (300 / 28 = 10.7): this setup produces an even shallower depth of field, but it allows really extreme macro photography!

To join the two objectives, you can use a special reversing ring, with male threads on both sides. Check the diameters of your lenses.

Compact digital cameras

Digital cameras, as said above (see “What “macro” means”, pg. 1), often feature closeup capabilities. If you want to go beyond closeup and enter the macro photography world, here are some options.

- Buy a “diopter” lens (or a series of lenses) to modify the focal length of the builtin lens. The quality of the resulting images depends, in turn, on the quality of both the lenses (main and auxiliary). Since such lenses are usually cheap, they might be worth a try.
- Buy or assemble a suitable adapter and use a reversed lens in front of the builtin lens (see “Using two lenses”, pg. 10). Even if the actual focal length of compact cameras' builtin lenses is very short, the crop factor of their small sensor has a strong mutiplying effect. In other words, the “35 mm equivalent” focal length is the value to be taken in account.
- Note that a LED ring can be used with builtin lenses also; more, it can be the only practical and portable light source for those compact models (the majority) that have

no external flash socket: note that, in many compact cameras, enabling the macro or supermacro mode will disable the builtin flash.

Traditional cameras

All the ideas exposed in this tutorial apply to traditional cameras too. Just keep in mind that “old” film cameras work with 35 mm full frames, so the focal length of their lenses does not benefit of a crop factor: the magnification ratio, for a given focal length, is the one given in table 1 (pg. 2).

Conclusion

Using a reversed lens can give good results; certainly it is an effective and very cheap way to enter the macro photography world. Due to the resulting extremely shallow depth of field, obtaining sharp images is the real challenge: in fact, a slight movement of the camera can significantly blur the subject. Some practice, indoor and outdoor, will help. When shooting, keep in mind the hints given in “Connecting the lens to the camera” at pg. 3... and hold your breath.

This tutorial is open to corrections, additions and refinements suggested by anyone.

Thanks for reading, and happy macro shooting.

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Appendix I – How to calculate the resistor value

Here's an example of the calculations needed to find a suitable resistor for a group of parallel LEDs.

Most common high intensity LEDs work at 3.5 ÷ 4 V, 80 mA. In this tutorial, we have connected 8 diodes in parallel (see inside "A homemade flash ring", from pg. 4): they all together, virtually, are a "bigger" LED, still working at 4 V, but 640 mA (80 mA x 8). Since the battery pack supplies 4.5 V, we should apply a resistor to lower the current by 0.5 V. Now, Ohm's Law tells that

$$(1)\ R = V / I$$

where

R = resistance, in Ohms
V = voltage, in Volts
I = current, in Ampère

So we have

$R = 0.5 \times 0.64 = 0.32$ Ohms

Again, Ohm's law tells that

$$(2)\ W = V \times I$$

where

W = power, in Watts

From (1), we have

$$(1b)\ I = V / R$$

By substituting (1b) into (2) we get

$$(3)\ W = V \times V / R = V^2 / R$$

So we have

$W = 0.5^2 / 0.32 = 0.78$

As a result, a 0.33 Ohms, 1 W resistor should be the commercially available component that best approximates the values we've found by applying Ohm's law. Since it must be connected in series, you can use it (instead of a chunk of electric cable) to wire the positive lead of the battery pack to the central lead of the switch.

Appendix II – Some sample images

The following images were taken using the 28-70 mm reversed lens (at 28 mm) and the LED ring, as explained above. They all depict a few centimeters wide areas; the images were resized to 400x267 px from the 3504x2336 px original shots.

Particular of a finger.

Particular of a small meadow flower.

Particular from the same above flower.

Mold on a tree. The shallowness of the depth of field is enhanced by the roundness of the surface.

Particular of a wool jumper.

Blow me away! ;-)

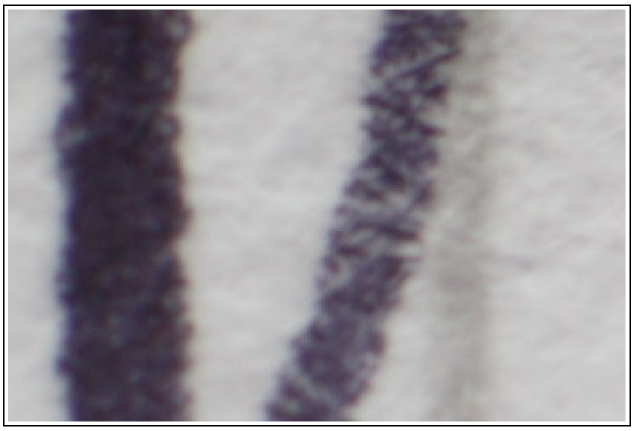
Appendix III – Light off, light on

The following two images show the difference between shooting without and with the LEDs on. They both were taken indoor, near a window, with the following settings:

- reversed 28 mm focal length
- f/5.6 aperture
- ISO 100

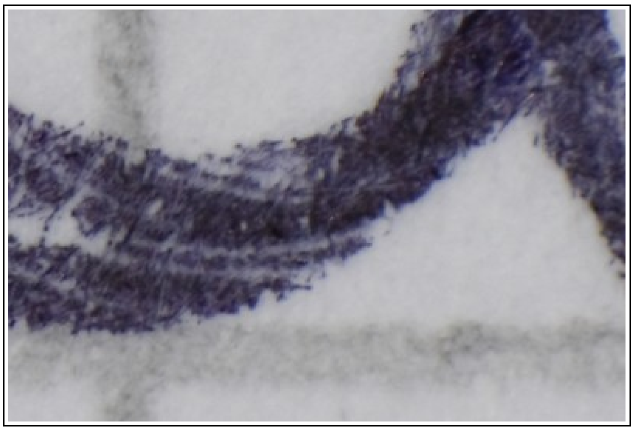
However, the LEDs were off while taking the first one: a 1/13 sec. shutter was needed to get the right exposure, while, after turning on the LEDs, a 1/160 sec. shutter allowed a good exposure.

Both the images represent particulars of the same handwritten sheet; the crop depicts an about 4.5 mm wide area.



LEDs off, 1/13 sec.

The natural light preserved some detail of the paper texture, but the long exposure resulted in a considerably blurred image.



LEDs on, 1/160 sec.

The intense light provided by the LEDs allowed a relatively fast shutter time: the paper texture is a little flattened, but the image is sharp.

Index