Infra-Red Snap Shots with Zuiko Digital Lenses - an IR-converted E-1

by Jens Birch

"Linköping Communal Library"

(IR-converted E-1 + Zuiko Digital ED 7-14mm/4.0 at 7 mm and f/8, ISO 200 and 1/60 second, handheld, no external IR filter can be used with this lens)

Introduction

Infra-red photographs taken of sunlit scenes have a striking look. I guess most of you E-system owners have seen such images, usually they are in black and white where the sky, which would have been bright blue in a colour photograph, is pitch black with white clouds, and leaves, which normally are green, shows up as radiant white.

Here is an example taken a sunny afternoon in May just after the oaks had gotten their leaves here in Östergötland (Sweden):

"Under the Oaks"

(IR-converted E-1 with ZD 14-54mm/2.8-3.5 at 14 mm, ISO 200, f/8, 1/100 second handheld, no external filter)

Capturing the scene using IR often gives a surreal feeling to the image - which isn't so strange if we think about it. Infra-red light is light that lies outside the visible spectrum and hence humans can't see it. However, most of the light coming from the sun is IR and it is reflected, more or less, from all objects around us, although we can't see it. What makes IR-photos intriguing and look a bit spooky is, except for being a photograph of something normally invisible, the fact that materials around us doesn't reflect IR in proportion to how much visible light they reflect.

This is demonstrated by these colour-, B&W-, and IR-photographs of an array of hats:

"Colour vs. B&W vs. IR"

Top pane: Ordinary picture taken with a Rodenstock UV+IR blocking filter at 1/640 second.
Mid pane: The same picture as in the top panel but converted to greyscale.
Bottom: Picture taken with a Hoya R72 IR-pass filter at 2 seconds.
(Both the visible and IR images were taken with an ordinary E-1 + Zuiko Digital 14-54mm/2.8-3.5 at 38 mm at ISO 200 using a tripod)

The hat materials in the image above are from the left: cotton, knitted wool, polartech® fleece, cheap fleece, and knitted acrylic.
Note how the synthetic materials reflect IR in an apparent unpredictable way. For example the black and grey fleece hat became inverted in luminance when imaged with IR light.

Have a look at the shooting details of the above images:
The visible light hat-comparison shot was taken at 1/640 second while the corresponding IR-shot was taken at 2 seconds although the sun was shining and the camera settings were otherwise identical except for the filters used. Obviously, the E-1 is quite insensitive to IR which is due to a special IR-blocking filter that is placed in-between the SSWF (super sonic wave filter) dust buster and the CCD-sensor chip front of the E-1. A fairly strongly blocking filter is needed in order to not allow IR-light to pollute the colour fidelity of the images captured by a digital camera (as has been a problem with the Leica M8). However, this IR-blocking filter also severely limits what you can photograph using a lens-mounted IR-pass filter (like the Hoya R-72 filter) in front of your objective lens with any Olympus E-system DSLR. One have to use a tripod and stick to static subjects - even clouds may become blurred in 2 seconds. Another drawback with using a lens-mounted IR-pass filter is that the viewfinder becomes blacked-out (because the IR-pass filter does not transmit any, or very little, visible light. That complicates both composition and focusing. Fortunately, the AF sensors of the E-1 are highly IR sensitive so AF still works.

Now, looking at the technical shooting detail of the two first IR image shown above, you see that thay were taken *handheld* with f/8 at 1/60 and 1/100 second, respectively. That was possible because I modified that E-1 body - I "IR-converted" it. That means, I removed the internal standard-mounted IR-blocking filter from the E-1 and replaced it by an IR-pass filter.

The major consequences of such an IR-conversion are:

- IR sensitivity is boosted by roughly a factor of 200
- it is possible to see and compose through-the-lens
- the camera becomes insensitive to visible light - depending on chosen IR-pass filter
- accurate focusing is not possible with Zuiko Digital lenses but legacy lenses with an IR-mark works fine

There are several companies offering such conversions of some Canon and Nikon models but so far, nobody volontarily makes IR-conversions of Olympus DSLRs. Now, after I made it myself, I understand the reason: One must undo 29 screws, remove 9 miniature flat cables, remove 3 printed circuit boards (PCB) (including the one carrying the CCD), and remove the SSWF before the filters can be swapped. The filter-swapping is in itself a non-trivial excercise in using mild violence, multi-tweezer coordination, and controlling ones

temper. All-in-all it takes about 4 hours to complete it - including filter cleaning and AF-adjustment. I'm glad I did it and to me, it was worth every effort:

"Snæfellsjökull"

A small glacier on the Snæfellsnes peninsula in southwestern Iceland.
The "Snæfellsjökull" panorama is composed of 4 HQ shots taken handheld with my IR-converted E-1 + 14-54 at 35 mm, ISO100, f/8 at 1/125 s. (The full sized panorama is 5288x2506 pixels² and will soon decorate my living room wall.)

The Conversion

I honestly didn't think it was a complicated operation when Tony Spore, the man behind fourthirdsphoto.com, contacted me and offered a joint effort to pioneer conversion of E-1 bodies: He provided a defected body for me to figure out how to do the conversion with. If the first conversion was successful, I would keep that body and make another IR-conversion for Tony himself. A fair deal which I accepted and, after having repaired the defect body and converted it and now seing what kind of fantastic images I can take handheld... WOW, I'm glad I learnt to know Tony so that I got this golden opportunity. I'd like to thank Tony for giving me this opportunity: Thanks Tony!

I am not going to provide a step-by-step DIY manual - rather the opposite - please read the disclaimer at the end of this article if you feel tempted to do this on your own. The reason for not making a detailed instruction is that I do not want to be responsible for someone else ruining his/her camera by taking it apart and then not being able to put it back in a functional state. There are many instances where one can go wrong and I do not recommend anyone without basic knowledge about optics, miniaturized electronics, as well as a good skill with fine-mechanical tools to do this. I do not want to spend hours helping people salvaging their cameras after a failed IR-conversion attempt.

However, I will now show you with a few images, representing the steps of the conversion, how the camera looks like inside and some details related to the IR-conversion. I hope it may be interesting to some of you:

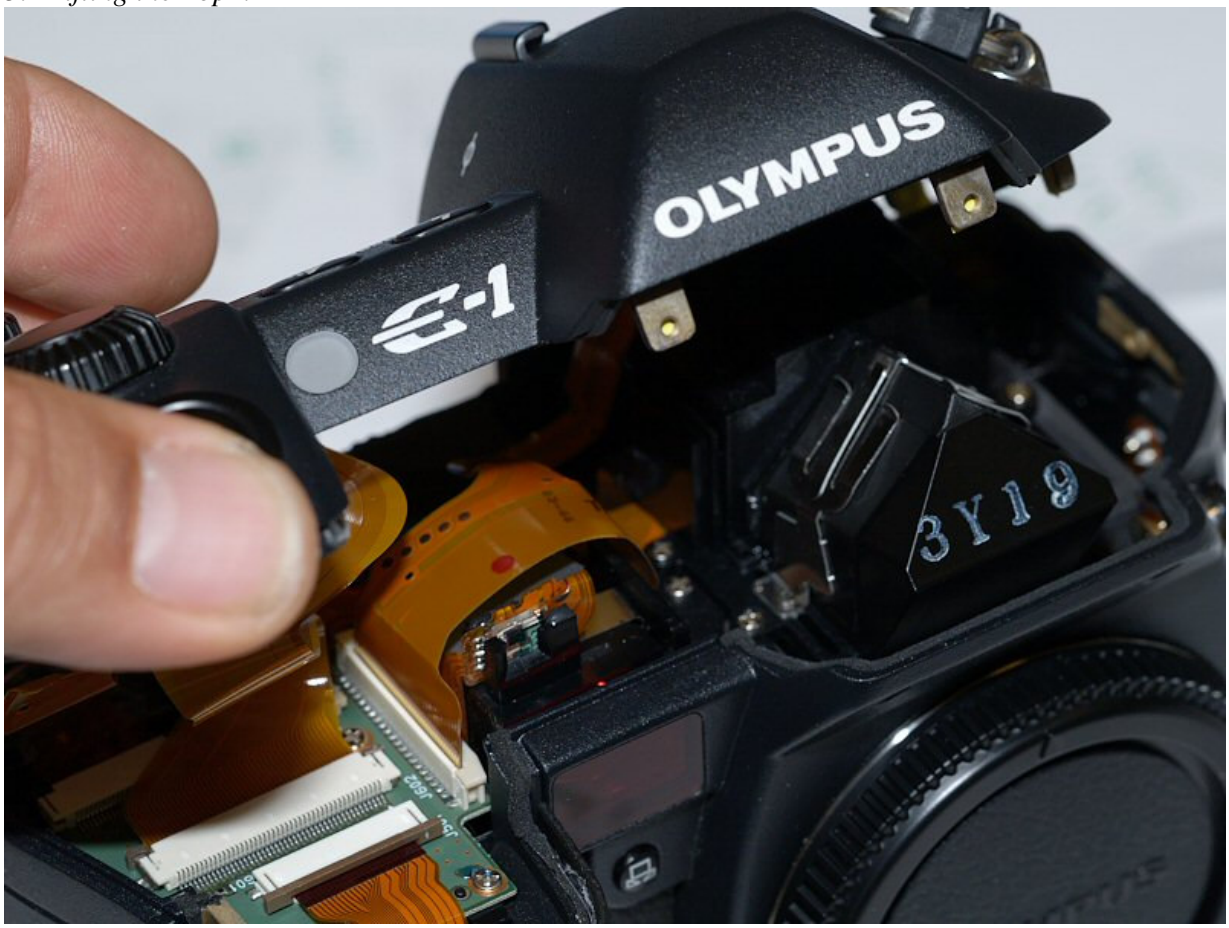
1. *"Removing the First Screw"*:

This is the only hidden screw - under the rubber.

2. *"Ready to Open"*:

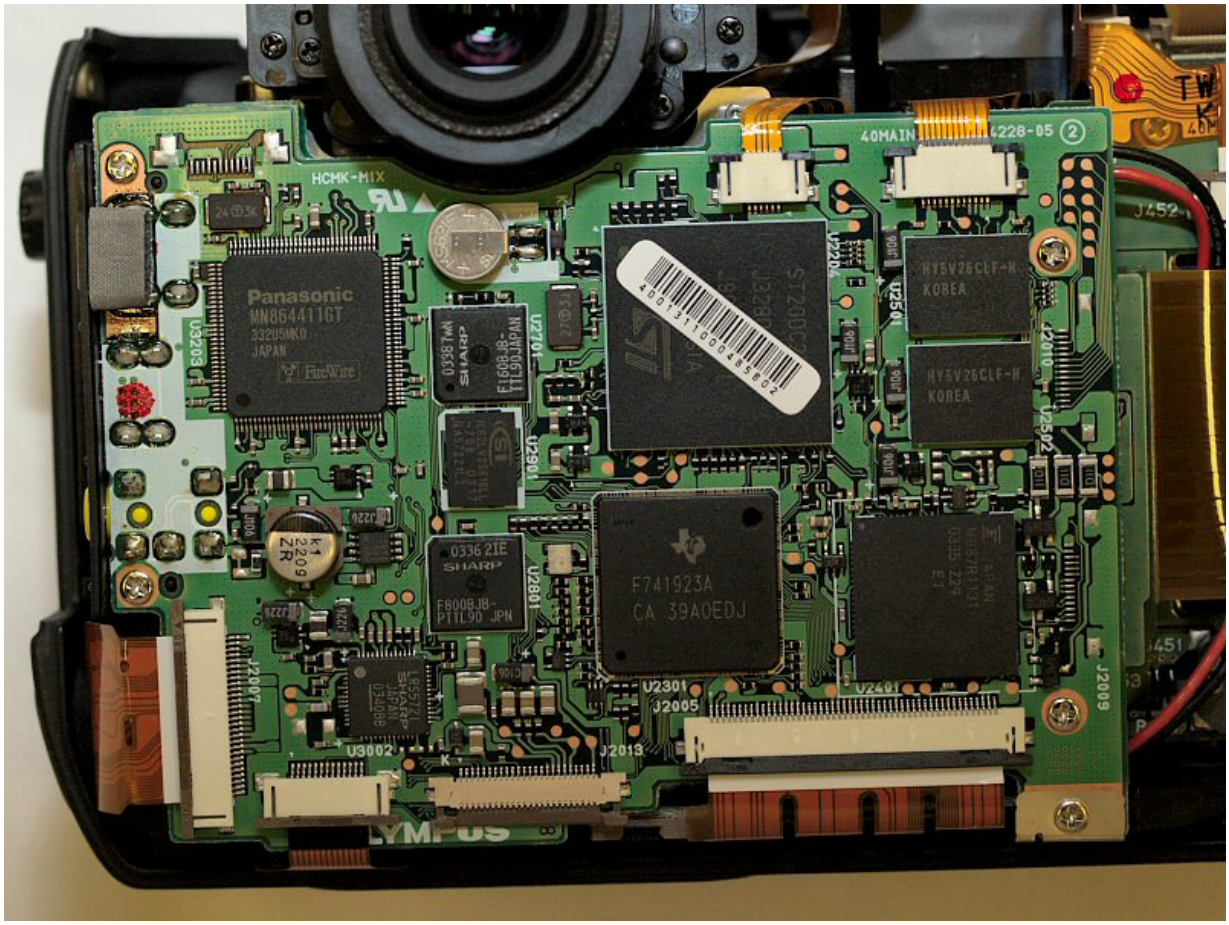
Keeping everything clean and tidy is essential. All screws are marked with the order they were removed and where they came from and scotched to the work-surface.

3. *"Lifting the Top"*:



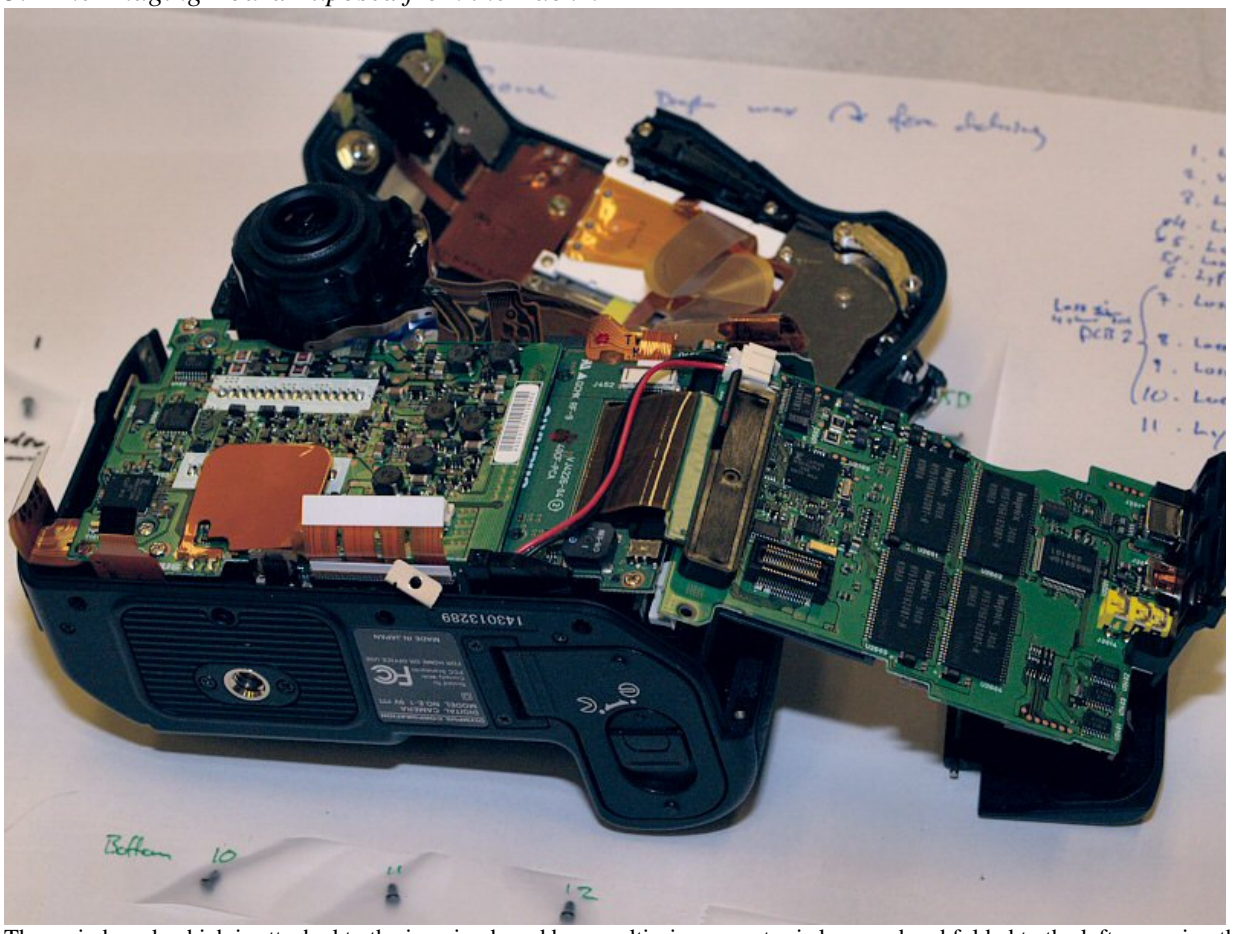
Lifting the top reveals the penataprism and to the left you can see the first printed circuit board (PCB #1) which is connected to the top by 2 mini-flat cables for the small LCD, buttons, and wheel, which should be detached. (BTW, the rumor that Olympus used a 35-mm-sized pentaprism for the E-1 is hereby killed.)

4. *"The Main Board"*:



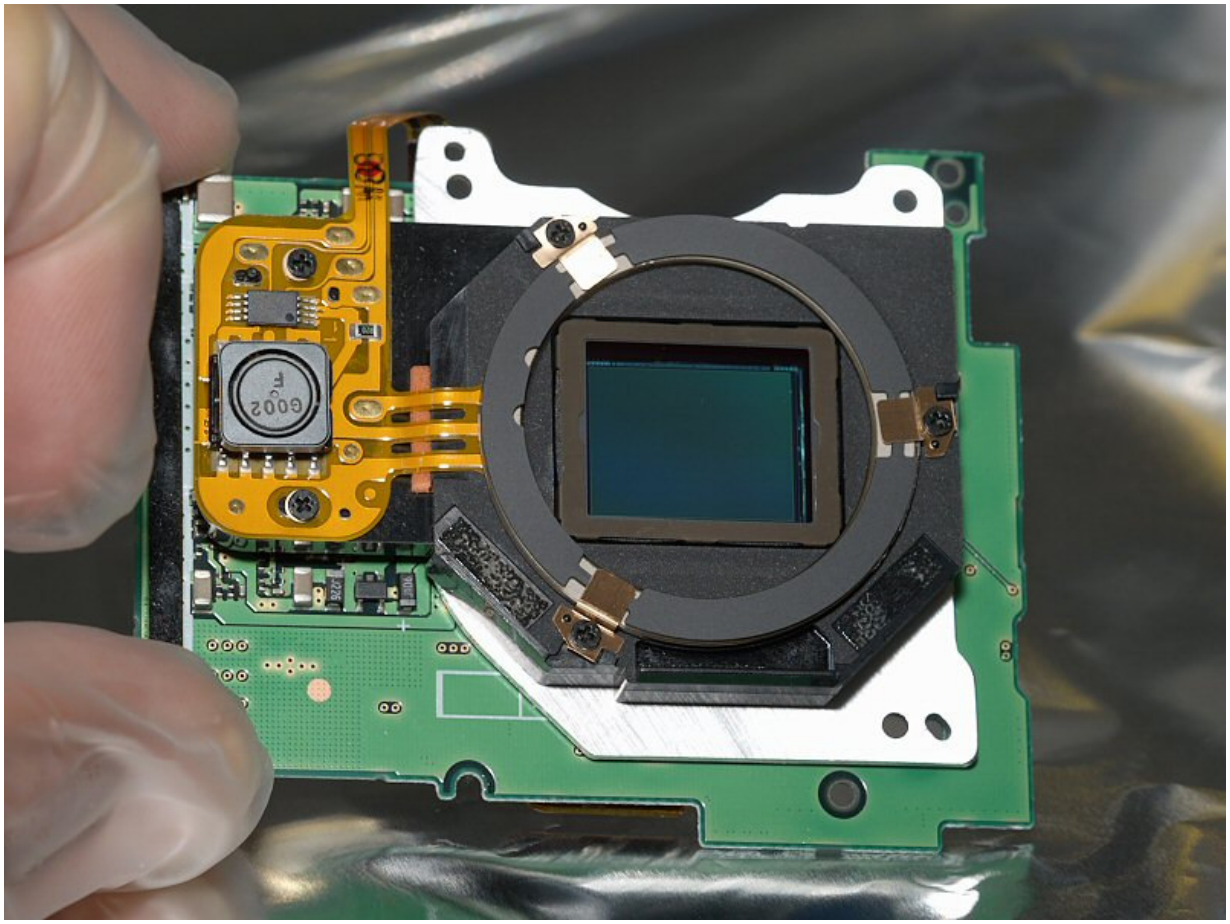
This is the main board which is revealed after loosening PCB #1, which in turn allows for removing the back cover and detaching its 2 mini-flat cables. There were 5 more mini-flat cables to detach from the main board before it could be removed. Amazingly though, none of the screws needed to be loosened - they just hold various piggyback cards in place, like the memory + CF controller-card. In fact, the main board is piggybacked onto the imaging board which holds the CCD.

5. *"The Imaging Board Exposed from the Back"*:



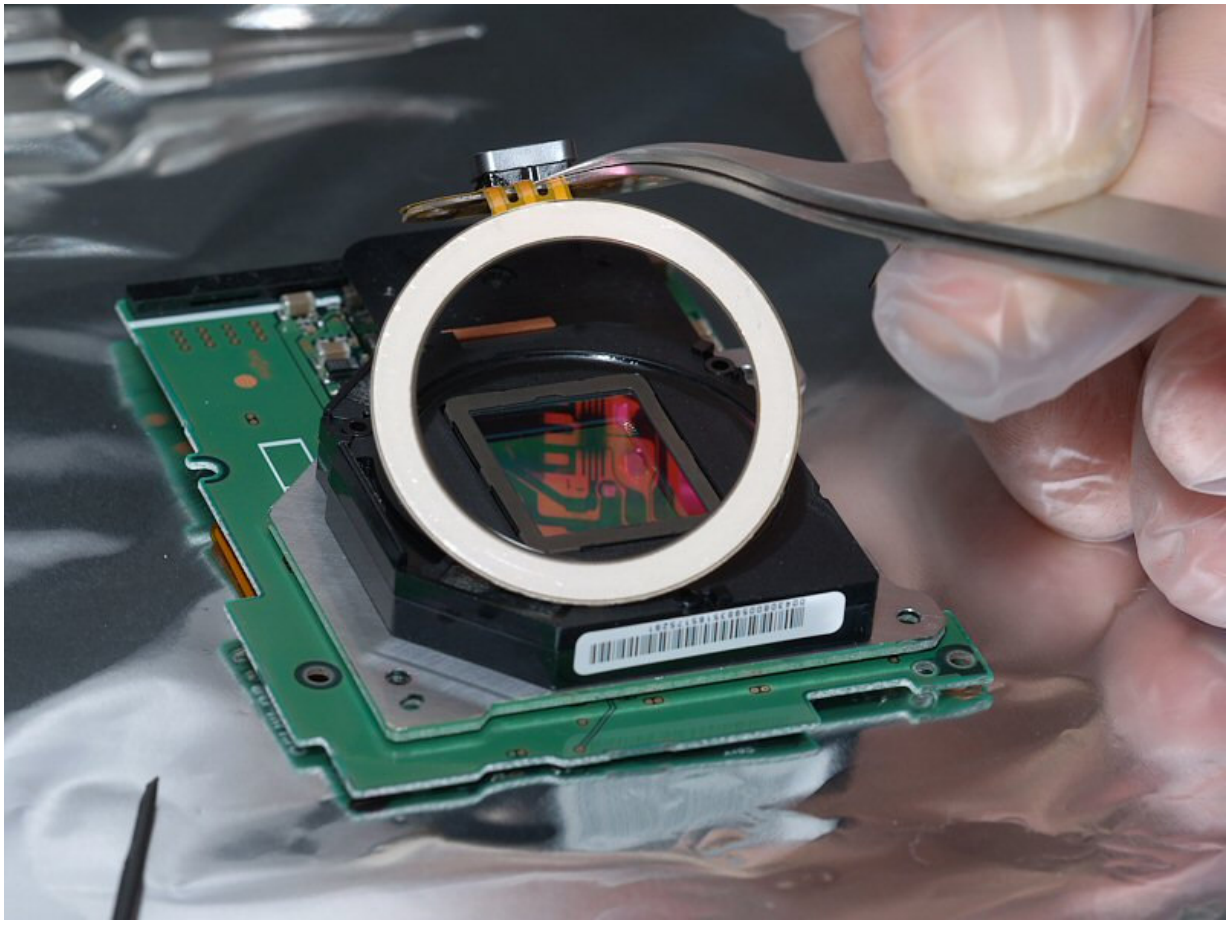
The main board, which is attached to the imaging board by a multi-pin connector is loosened and folded to the left, exposing the back of the imaging board. The row of sturdy soldered pins, seen on a white background rectangle just under the eye-piece, are half of the connecting pins to the CCD which faces the other way on the other side of the board. It is backed by a relatively thick Aluminium plate which provides the cooling of the CCD. Now the imaging board was *carefully* removed by first loosening 6 screws (3 holding the CCD by the Al-backing plate) and lifting it right up. There are tiny shims of various thicknesses between the Al-plate and 3 of the screw seats ensuring the CCD is aligned parallel to the imaging plane and held at the correct distance from the lens mount.

6. *"Imaging Board Before Conversion"*:



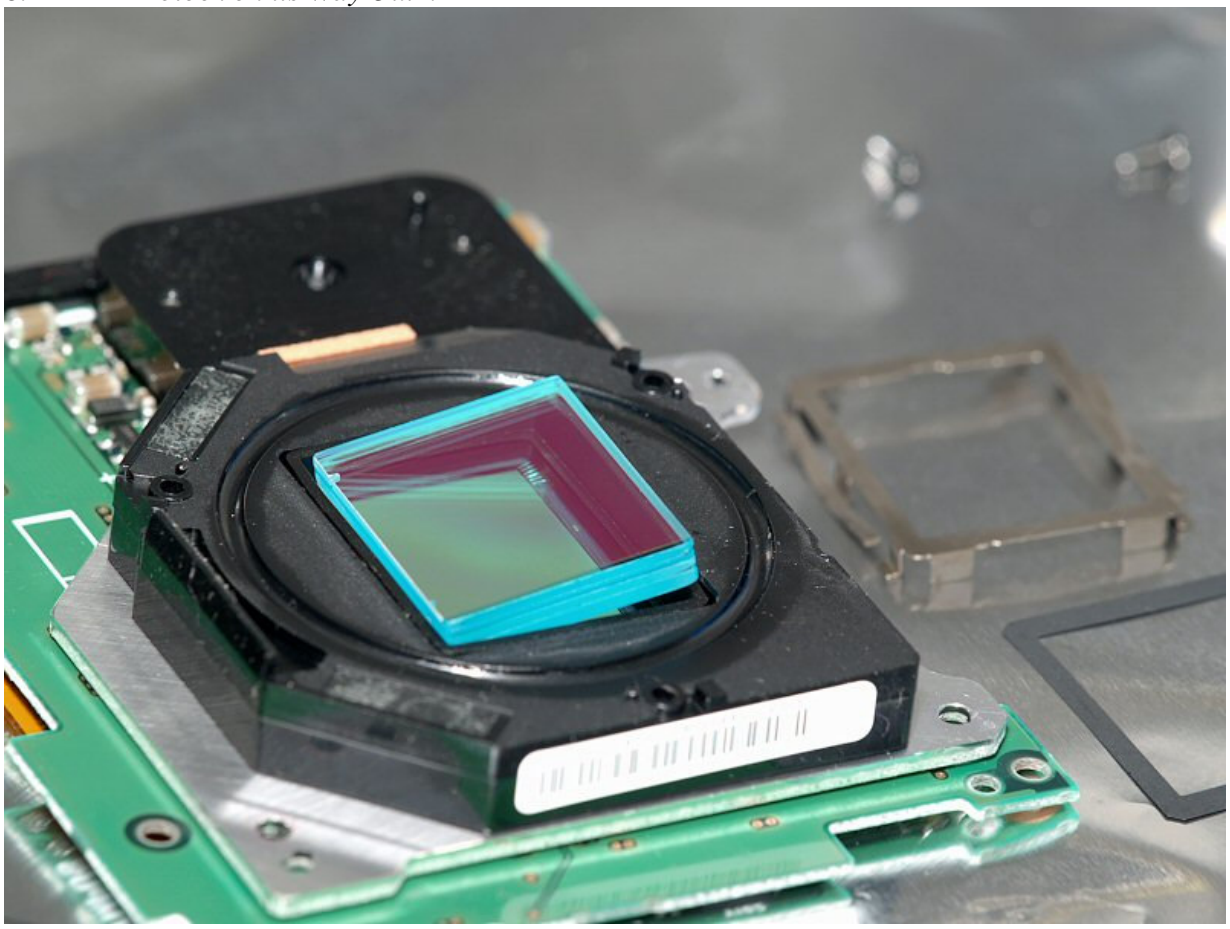
Here you can see the rectangular CCD behind the likewise rectangular combined IR-blocking and Anti Alias (AA) filter which, in turn, is behind the large circular SSWF dust buster. The two rectangular pads sitting at 45° below the SSWF are the "sticky goo pads" that collects the dust shaken off the SSWF
dust buster.

7. *"Dust Buster without Power"*:



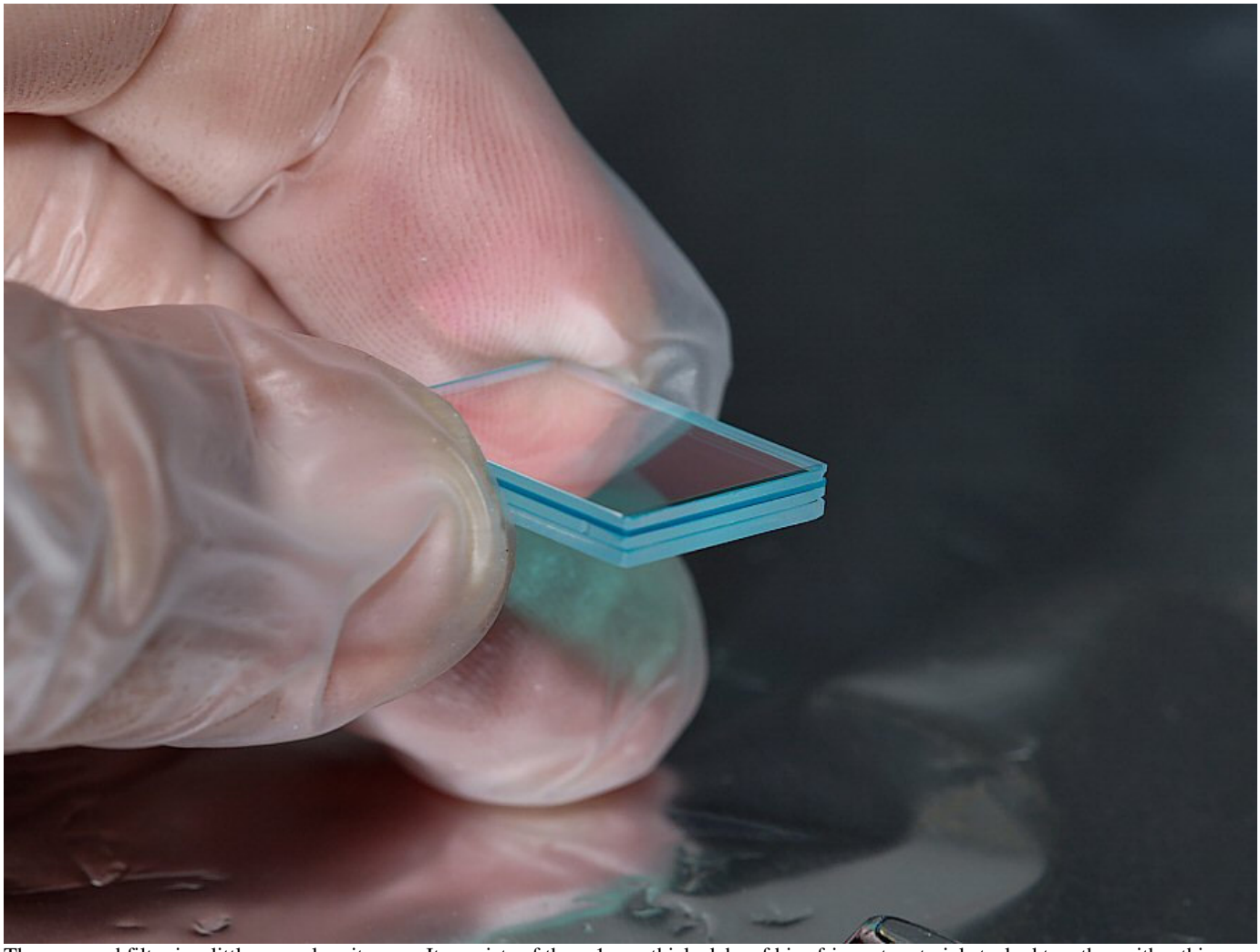
I am removing the SSWF filter after loosening its dedicated PCB and the electrical connectors to the filter. Underneath the filter is an O-ring to keep dust out of the assembly.

8. *"AA + IR-block on its Way Out"*:



The combined AA and IR-blocking filter is on its way out of the CCD package. Getting the rectangular metallic retaining frame out (seen in the background) was the second hardest step in this process. Putting it back was no doubt harder than all other steps together. *It made me sweat!*

9. *"A Jewel"*:

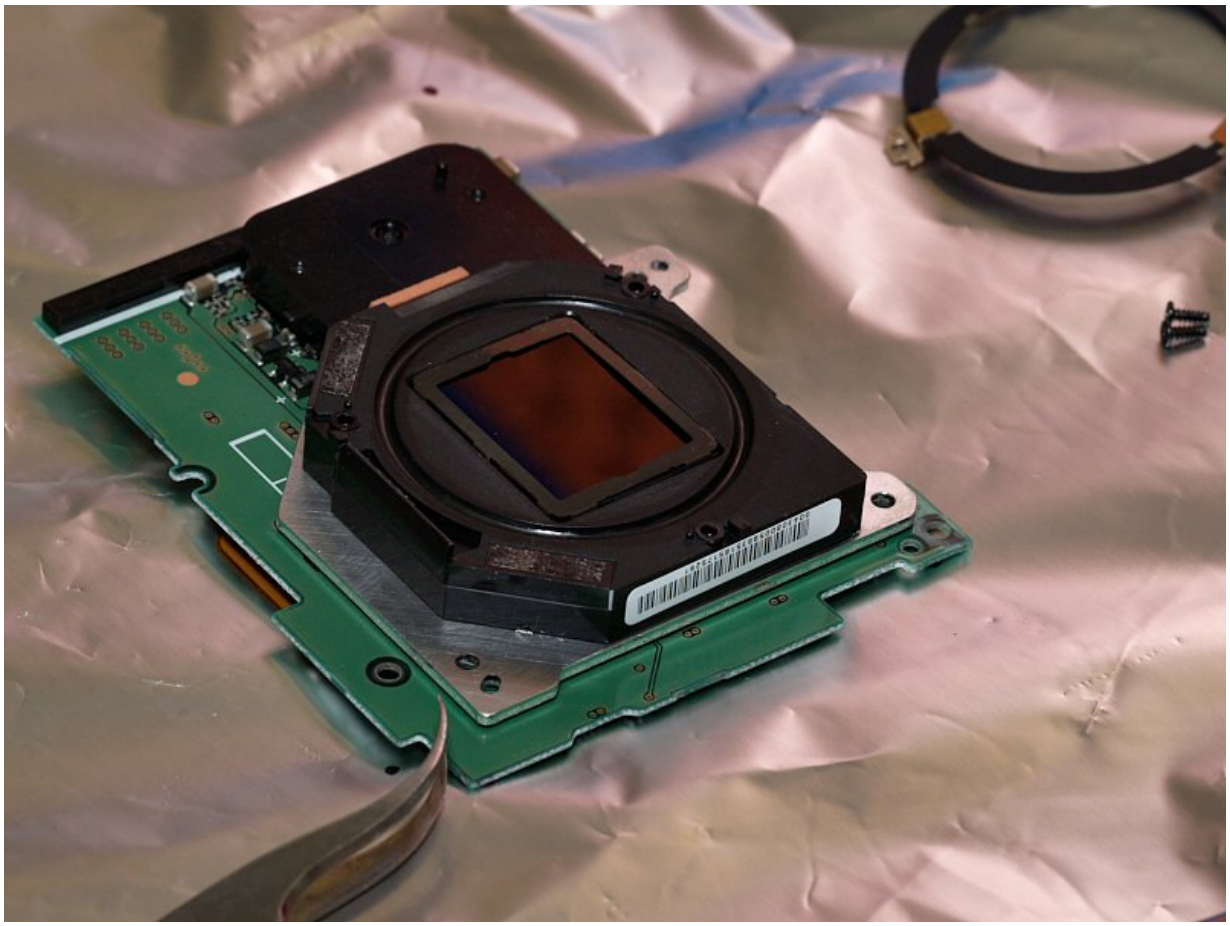


The removed filter is a little marvel on its own. It consists of three 1 mm thick slabs of bi-refringent material stacked together with a thin IR-filter (the blue layer squeezed into the stack in figure above).

10. *"The New Filter"*:

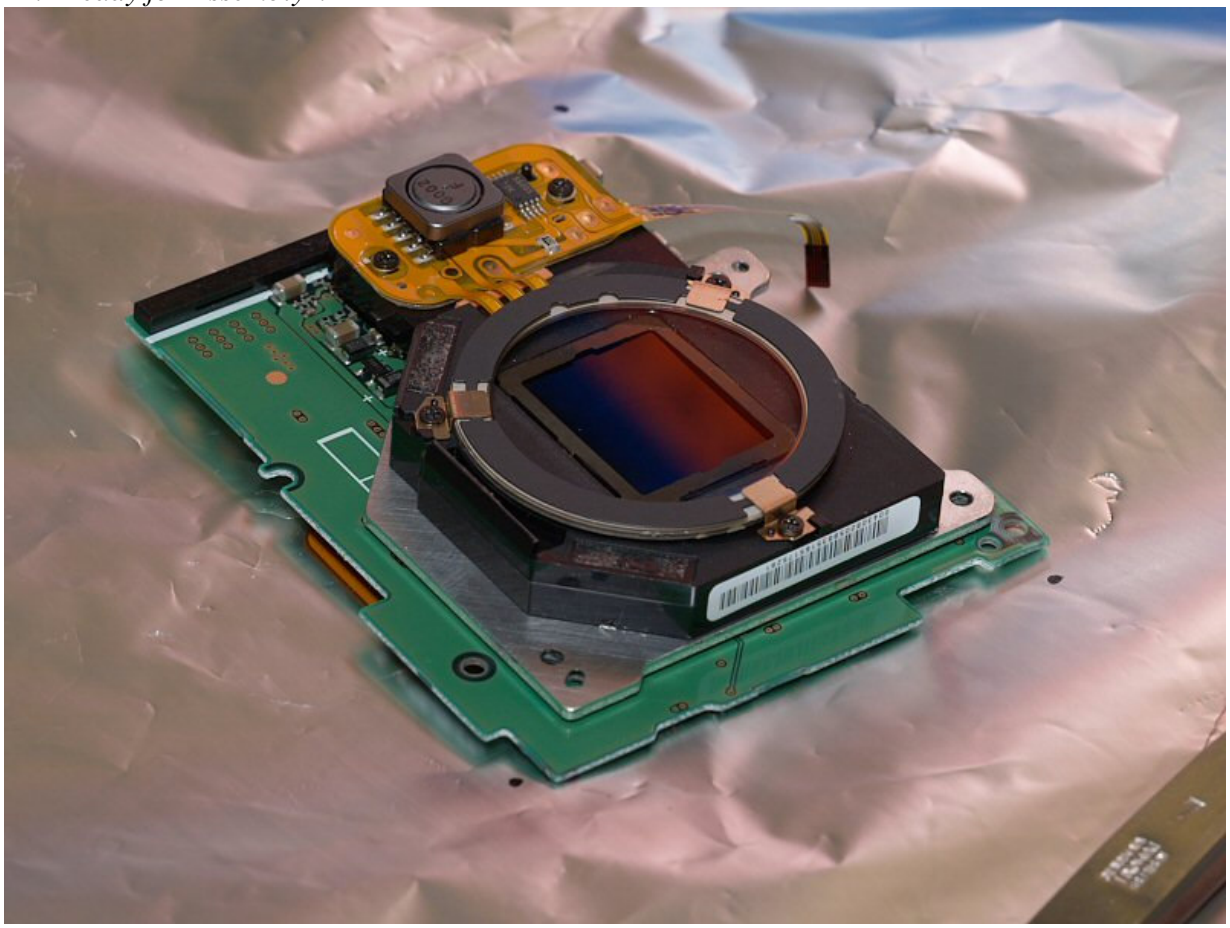
The new IR-pass filter (3 mm Schott RG780) is waiting in its ultrasonic cleaning fixture, ready to be put in place.

11. *"New Filter in Place"*:



The new filter in place in front of the CCD.

12. *"Ready for Assembly"*:



The imaging board complete again with the IR-pass filter in place behind the SSWF. Now starts the assembly - that is doing the above in reverse...

Finally, I adjusted the Auto Focus so that it works perfectly with all Zuiko Digital lenses. However, I did not adjust the Manual Focus because that would make it impossible to accurately focus non-AF legacy lenses.

That concludes my guided tour through my 'conversion fab', I hope you found it interesting.

Some Images:

Here follows a little display of images showing what can be done with this body. They are all taken handheld with a minimum of post processing applied:

"Swedish Farm in Snow":

(IR-converted E-1 + Zuiko Digital 14-54/2.8-3.5 at 20 mm and f/5.6, ISO 200 and 1/160 second)

"Old Swedish Farm":

(IR-converted E-1 + Zuiko Digital 14-54/2.8-3.5 at 33 mm and f/5.6, ISO 200 and 1/250 second)

"Blooming Sherry":

(IR-converted E-1 + Zuiko Digital 14-54/2.8-3.5 at 14 mm and f/8, ISO 400 and 1/400 second)

"Breidavik from Arnastapi"

(IR-converted E-1 + ZD 14-54 at 38 mm and f/8, ISO 100 and 1/125 second, handheld panorama composed of 5 images.)

"Black Beach at Vik":

(IR-converted E-1 + ZD ED 7-14/4.0 at 7 mm and f/8, ISO 100 and 1/200 second)

"Playing Kids"

(IR-converted E-1 + Zuiko Digital 14-54/2.8-3.5 at 54 mm and f/5.6, ISO 100 and 1/1250 second)

"Swans over Cranes"

(IR-converted E-1 + Zuiko Digital ED 50-200/2.8-3.5 + EC-14 at 283 mm and f/5.6, ISO 400 and 1/800 second)

IR-technique and Special Features

I'd like to finish with a few words about how it is to shoot with an IR-converted body and about some side effects.

Exposure

The sensitivity to IR is about 200 times greater than before the conversion so no tripod nor IR-filter on the lens is needed. This makes for a great setup to experiment a lot. One will find a few peculiarities with IR-light and camera metering.
In natural daylight, the invisible IR-light does not follow the visible light in intensity mainly because IR light is much more hindered by clouds to reach the earth than visible light and the blue sky doesn't emit any IR. Therefore, if the visible light conditions change a little, one can be almost 100% sure that the IR-light conditions changed a lot. Likewise, the dynamic range of the IR in one single sunlit scene often appears to be much greater than when using ordinary light.
One must keep in mind that the camera meters using both visible and IR light and when the relation between the two types of light change, one must dial-in a different exposure compensation. The best way to learn what happens to the IR light is to take a lot of photographs and check the histogram. For this, an IR-converted DSLR is ideal because of the effortless way one can capture the images and check the result. After a while one learn to know the appropriate exposure compensations by heart.

White Balance

Regarding white balance of IR photographs, there is really no correct or incorrect setting. We can't see the IR-light in the first place - so how should we then assign any colours to it?
My personal take on this is that I like my IR-shots to be shown as B&W. The reason is that my IR-conversion, using a filter that cuts away visible light below 780 nm makes the camera blind to red, green and blue and the red-, green-, and blue-filtered photosites on the sensor are roughly equally sensitive to IR above 780 nm (the red ones are a bit more sensitive). Equal amounts of those colours are rendered white. Hence making a white balance off any IR source (I prefer the sun) seems natural and will yield pleasantly looking pseudo B&W images with plenty of nearly greyscales. I wrote "pseudo" and "nearly" because the image actually contains a lot of slightly coloured pixels but our eyes will see them all together as grey with very rich tonality. You can easily see that in some of the shots above, like the *"Linköping Communal Library"* and the *"Old Swedish Farm"*. Also, to illustrate the Red photosites' higher sensitivity to red light, I intentionelly did not make any 100% B&W WB of *"Swedish Farm in Snow"*.

Of course one can use other filters than the Schott RG780 that I used and get a different response. However, the difference will mainly be in the amount of visible light that is let through the filter so that the image becomes mixed visible and IR. For example the Hoya R72 is such a

filter. The result is a very redish cast. This can also be white balanced but one can also be creative and play with the visible colours. For example it is very common to swap the red and green or red and blue channels of the images rendered through such a filter. The result is a dreamy feeling with totally off colours. IMHO, that is more creative photography and has very little to do with IR-photography. Similar effects can be achieved by manipulating ordinary shots as well.

Moiré and Resolution

An interesting side effect of the IR-conversion is thatthe *anti-alias* filter is removed simultaneously with the IR-blocking filter. (The AA-filter is a filter which, in a very well controlled manner, blurs the image a tiny bit before the light reaches the sensor. The reason is to avoid interference (so called Moiré) between the periodic array of photosites on the sensor chip and any periodic part of the image with similar repetition length.) So, the camera becomes more sensitive to Moiré but at the same time the images look a bit more crisp straight out of the camera.

As a curiosity, I can also mention that since the R, G, and B photosites are roughly equally sensitive to IR, it is possible to achieve a photosite-by-photosite resolution with an IR-converted body. However, one have to use a very basic RAW converter where it is possible to disable the Bayer interpolation. In this way I have managed to squeeze out the theoretical photosite-by-photosite resolution from this E-1 by using Dcraw with the command: "dcraw -d -r 0.9, 1.06, 1.13, 1.05 -b 0.85".

Conclusion

I managed, although not easily, to convert an Olympus E-1 to an IR-only body and I am having a lot of fun with it. The ease with which I now can take IR-photographs and the magic light that is rendering the image makes everything around me a potential subject with new and un-discovered photogenic qualities. For example, I am very much looking forward to capture the IR-pale - almost transparent - skin tones of human beings this summer.

Epilog:

This article is in response to many requests to tell a story about how I did the IR-conversion. Please note that the information in this article is solely an article with the intention to show some of the E-1 internals and to illustrate what I did for the technically interested E-system user.

I have the highhest respect for my readers and I'm sure you understand that this article is *not* an instruction for making an IR-conversion. However, I can't take anything for granted and I don't know the law in many of the countries this document will be read so I have to assume that someone will destroy their camera and blame it on me. Therefore, I need to include the following not so friendly disclaimer:

DISCLAIMER:

THIS ARTICLE MAY CONTAIN ERRORS THAT CAN BE FATAL FOR ANY CAMERA.
DO NOT USE IT AS AN INSTRUCTION.
I TAKE NO LEGAL OR ECONOMICAL RESPONSIBILITY FOR ANY DAMAGE OR LOSS OR OTHER NEGATIVE EFFECTS ON ANY CAMERA, LENS, BUSINESS, PERSONAL HEALTH, ETC. DUE TO ATTEMPTS TO MAKE IR-CONVERSIONS, MODIFICATIONS, OR OPENING A CAMERA, BASED ON THE INFORMATION PROVIDED IN THIS ARTICLE.
IF YOU ATTEMPT TO DO THIS ON YOUR OWN - **YOU *ARE* ON YOUR OWN** - I WILL NOT RESPOND TO ANY APPEALS FOR HELP.