

1. BMW Radio Navigation Indianapolis mod II

Part II: Traffic Pro meets Indianapolis

Some time ago I replaced the Becker/BMW Professional RDS radio unit in my 8 series with a Becker/BMW Radio Navigation Indianapolis. You can read about my motivation in an earlier thread: [Becker/BMW Radio Navigation Indianapolis mod](#). In short, I was looking for a modern high quality radio/cd player with mp3 support which integrates nicely in the E31's interior. I'm not a fan of catchy head units with animated multi color displays, thus the choice for the Indianapolis was a logical one because of its OEM-like appearance.

The problem with the Becker/BMW Radio Navigation Indianapolis is the positive display (black text on an illuminated background) whereas the car uses negative displays (illuminated text on a black background) all around. Although I'm updating some items on my 8 to today's standards, I also try to keep the car's stock appearance as much as possible. As you can see in [my other thread](#) and the [Cd Box modification](#), I go quite far in this.

After inverting the Becker/BMW Radio Navigation Indianapolis' display from positive to negative, a blueish shine left (the display background was not black but rather dark blue). This effect is caused by the polarization filter I used. In the dark the blueish shine is invisible, but in bright daylight it is visible. The brighter the light, the more blue the background. Although I was very happy with the display mod at first, the blueish shine began to annoy me more and more.



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First I intended to experiment with other polarization filters, but sadly these filters are not really available in my different types to end users like you and me...

The Indianapolis' predecessor, the Becker Traffic Pro, does have a negative display (which can be switched to positive by software control). The Traffic Pro was also made in a BMW edition with correct BMW orange illumination: the Becker/BMW Radio Navigation Traffic Pro. On pictures I found of it, the display looked always lovely black with at most a slight brownish shine. Just like the other displays in the E31. Too bad the Traffic Pro lacks mp3 support which was one of the key features for taking the Indianapolis. Also, (personally) I believe the Traffic Pro is one of Becker's lesser designs.

The more I looked at the Traffic Pro, the more it appeared to me the differences with the Indianapolis are rather small. Sure, the design is different but the display seemed to have the same dimensions and the display style looked almost identical. Chances were good both units featured the same display - apart from the polarization filters making the Traffic Pro's display negative and the Indianapolis positive. For a while I thought about swapping the Indianapolis's display with one from a Traffic Pro.

But I got stuck on a problem: The display of the Indianapolis is connected to the printed circuit board (PCB) by a flexible plastic foil on which a large number of very thin conductive traces are printed. After a few careful attempts I came to the conclusion that it's impossible to release the foil from the PCB without damaging it beyond all repairs. I'm a seasoned hobbyist, but this would be something I can't fix. Furthermore the trace density is so high it would be practically impossible to solder by hand. Bad luck.

I couldn't let the Traffic Pro go, though. Apart from the similarities of the display it's striking the amount of buttons around the display is also the same. Just as the Indianapolis the Traffic Pro features a removable front with virtually the same dimension. The row contacts on the rear side of the removable front is at the same location and has the same number of contacts. All feature-wise differences (like mp3 support) are in the electronics inside the main unit itself and not on the removable front. So the idea grew that the hardware differences between both fronts is rather small. Automatically the idea came: Would the electronics in the Traffic Pro's removable front work on the Indianapolis? And in connection to that: Would it be possible to fit the Traffic Pro's electronics in the removable front of the Indianapolis?

The only way to find out is by experiment. After a bit of searching I got myself a removable front of a Becker/BMW Radio Navigation Traffic Pro. Of course second hand to keep the price low (in case of failure), but the unit is like new.

Front and rear side of the Becker/BMW Radio Navigation Indianapolis:





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De display on the first picture shows an extremely blue background. This is caused by the bright light I used and angle I shot the picture at. In real life the display looks dark blue to black-blue.

Front and rear side of the Becker/BMW Radio Navigation Traffic Pro:



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The black display is quite a difference to that of the Indianapolis. Despite the same bright light for the photograph, there's not a single trace of a blueish shine. Perfect. Too bad I couldn't find such polarization filter for the Indianapolis display.

As you can see there are many resemblances between the Traffic Pro and Indianapolis. But is this also true for the insides?

Rear side of the Becker/BMW Radio Navigation Indianapolis PCB:



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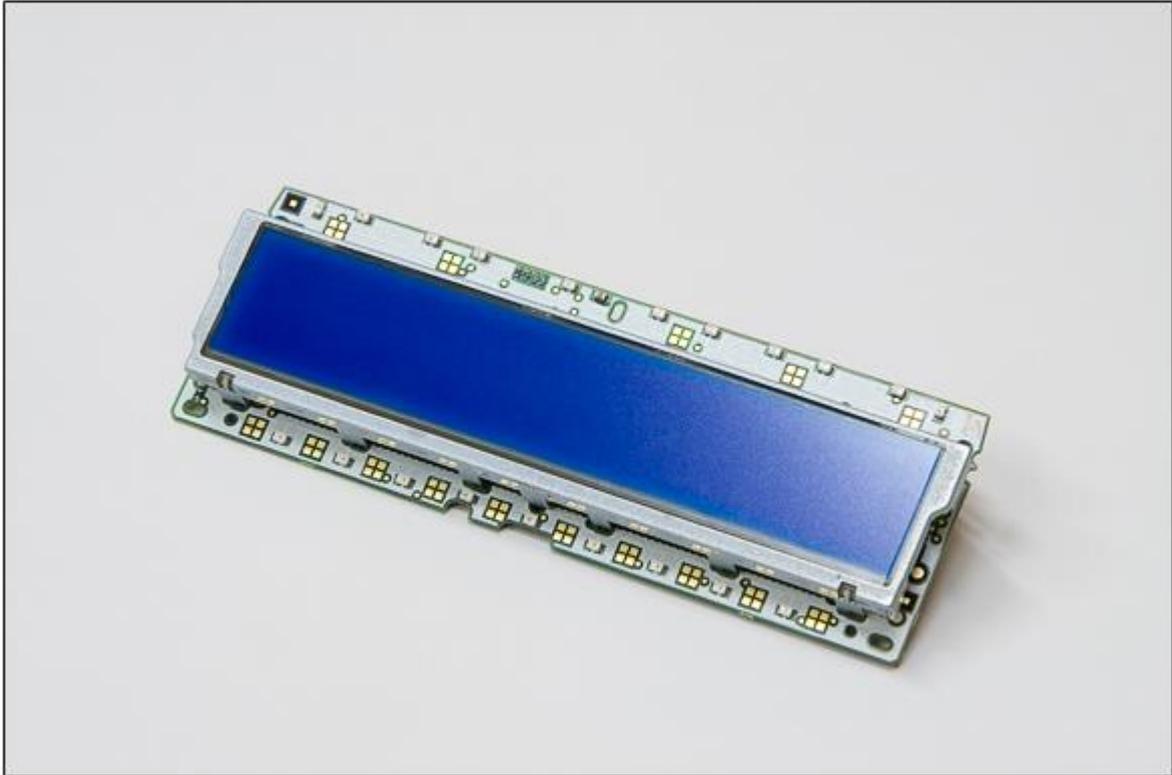
Rear side of the Becker/BMW Radio Navigation Traffic Pro PCB:



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If you like carefully you'll see several differences, but for the rest both PCBs are practically identical. The Indianapolis is definitely not a brand new design, but rather a follow-up based on the Traffic Pro. Of course this doesn't mean the Traffic Pro front will work with the Indianapolis.

Front side of the Becker/BMW Radio Navigation Indianapolis PCB with display:



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Front side of the Becker/BMW Radio Navigation Traffic Pro PCB with display:



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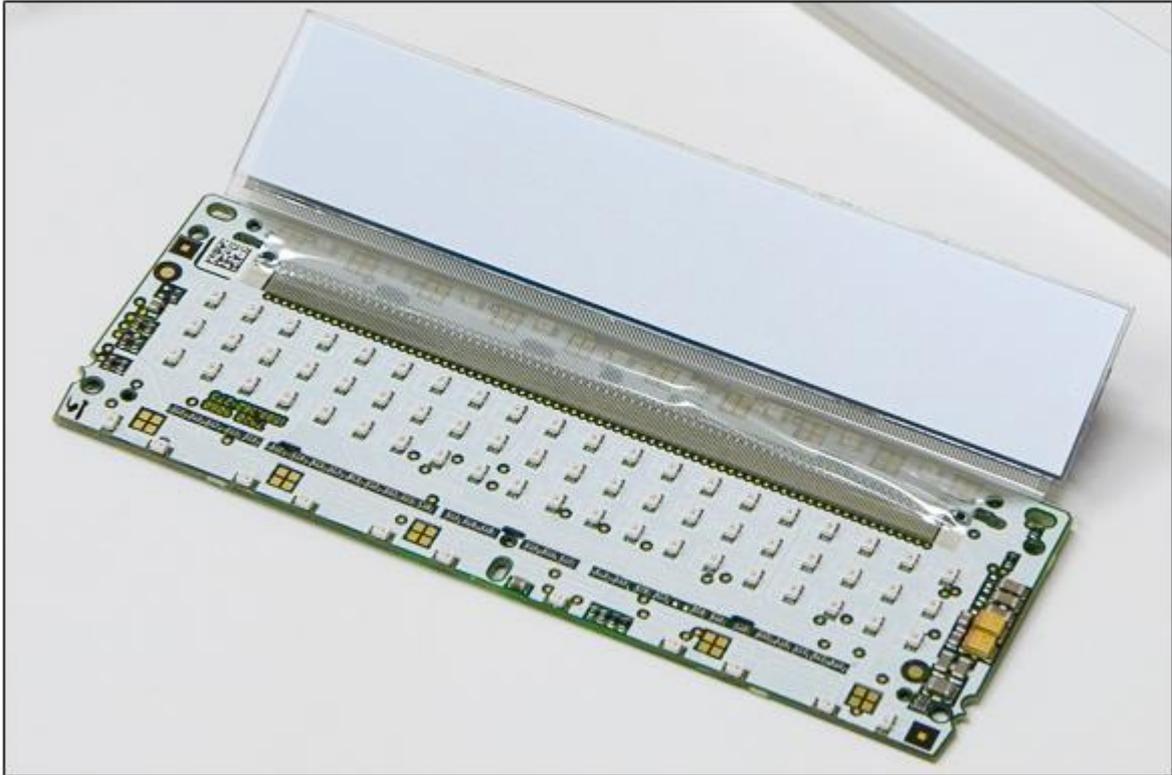
Again, the Indianapolis display is extremely blueish due to the setup I used for the photograph

The removable front of the Traffic Pro doesn't fit in the Indianapolis due to the somewhat different design. But with the PCB out of its case I could put it on the Indianapolis and push it by hand to make contact. So finally I could test whether or not the Traffic Pro front shows any signs of life on the Indianapolis. Because I short of hands while doing this I don't have pictures of this first test session.

Keep the PCB in place, turn on the power supply en then turn on the radio unit... Noting for a moment, but immediatly after that a bright orange BMW logo appears followed by the question to enter the radio code! A small celebration was at its place here. The Traffic Pro display is - I must admit - a lot better than the result of my own polarization filter mod on the Indianapolis. The contrast ratio is much higher and the orange a lot brighter. De brightness and background color (black to dark brown) now matches those of the old Becker/BMW Professional RDS with as difference the software controllable brightness of the Indianapolis. This way I can match the display's brightness perfectly to the rest of the car. I don't think I'll find better than this. This is exactly what I was looking for. Operating the switches on the PCB (actually contact pads instead of real switches) with only a few fingers free isn't easy, so I couldn't test the unit very thouroughly. At first sight everything worked, thus reason enough to continue the mod.

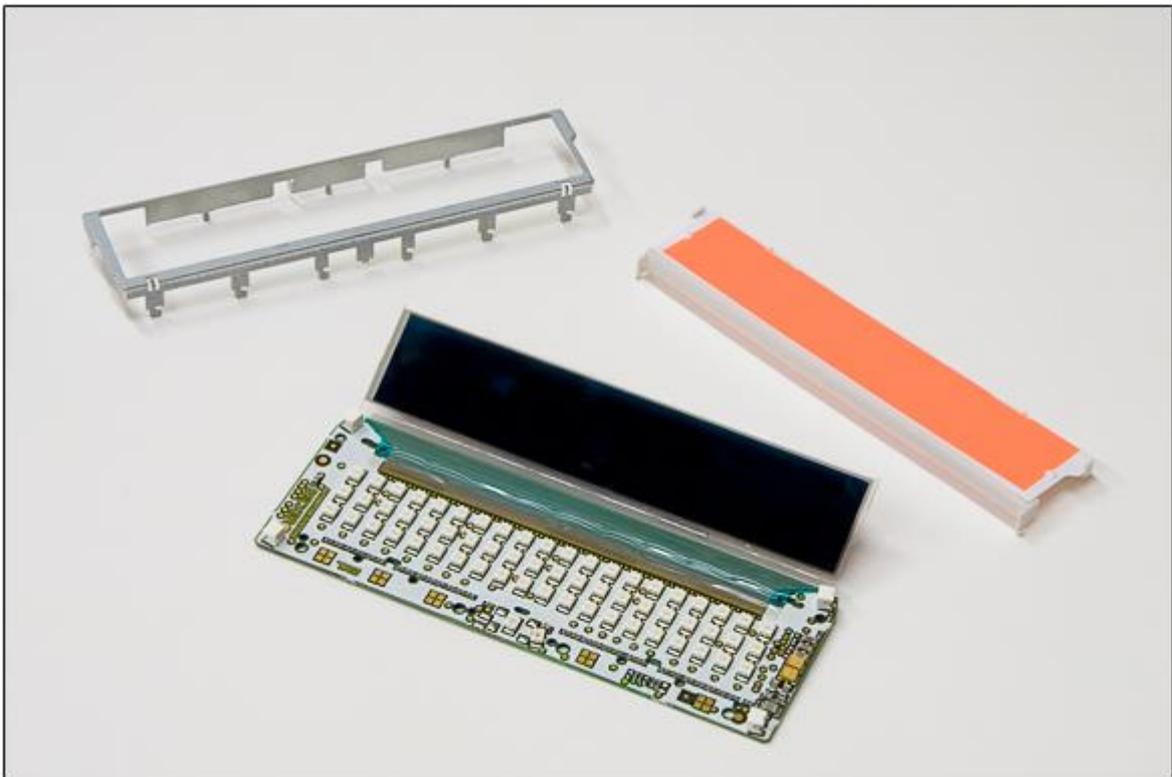
Becker/BMW Radio Navigation Indianapolis PCB with folded back display:



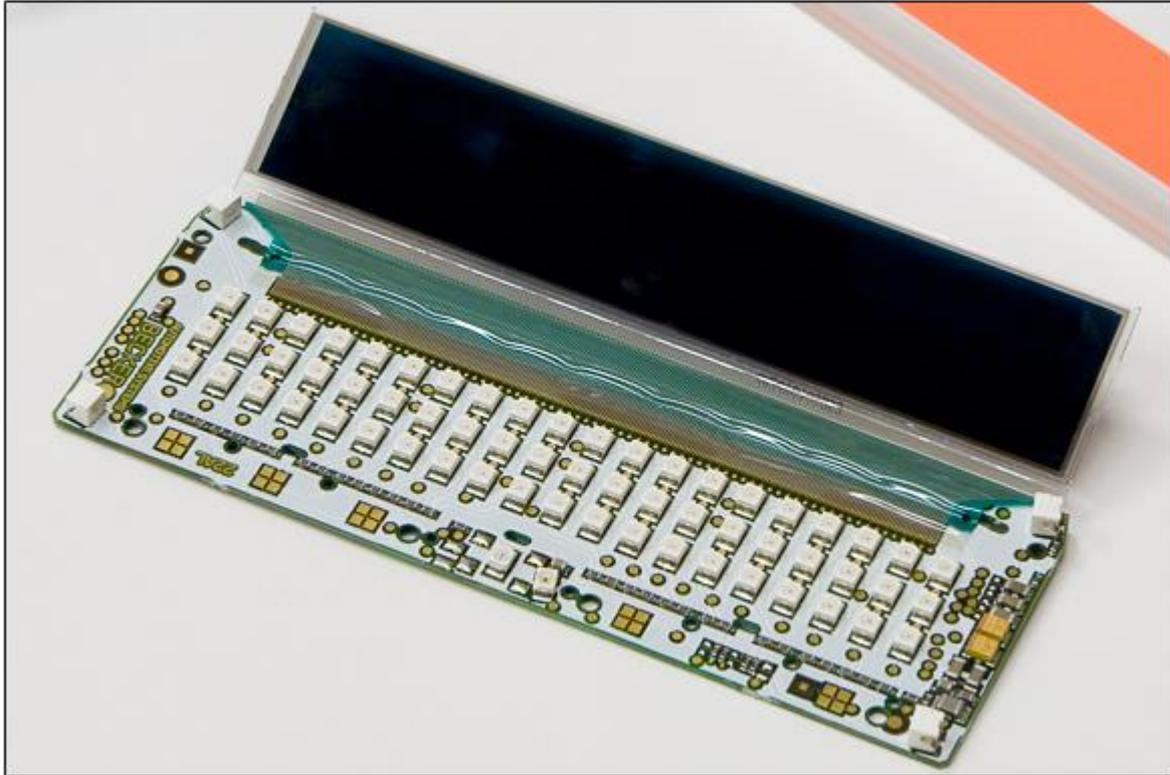


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Becker/BMW Radio Navigation Traffic Pro PCB with folded back display:



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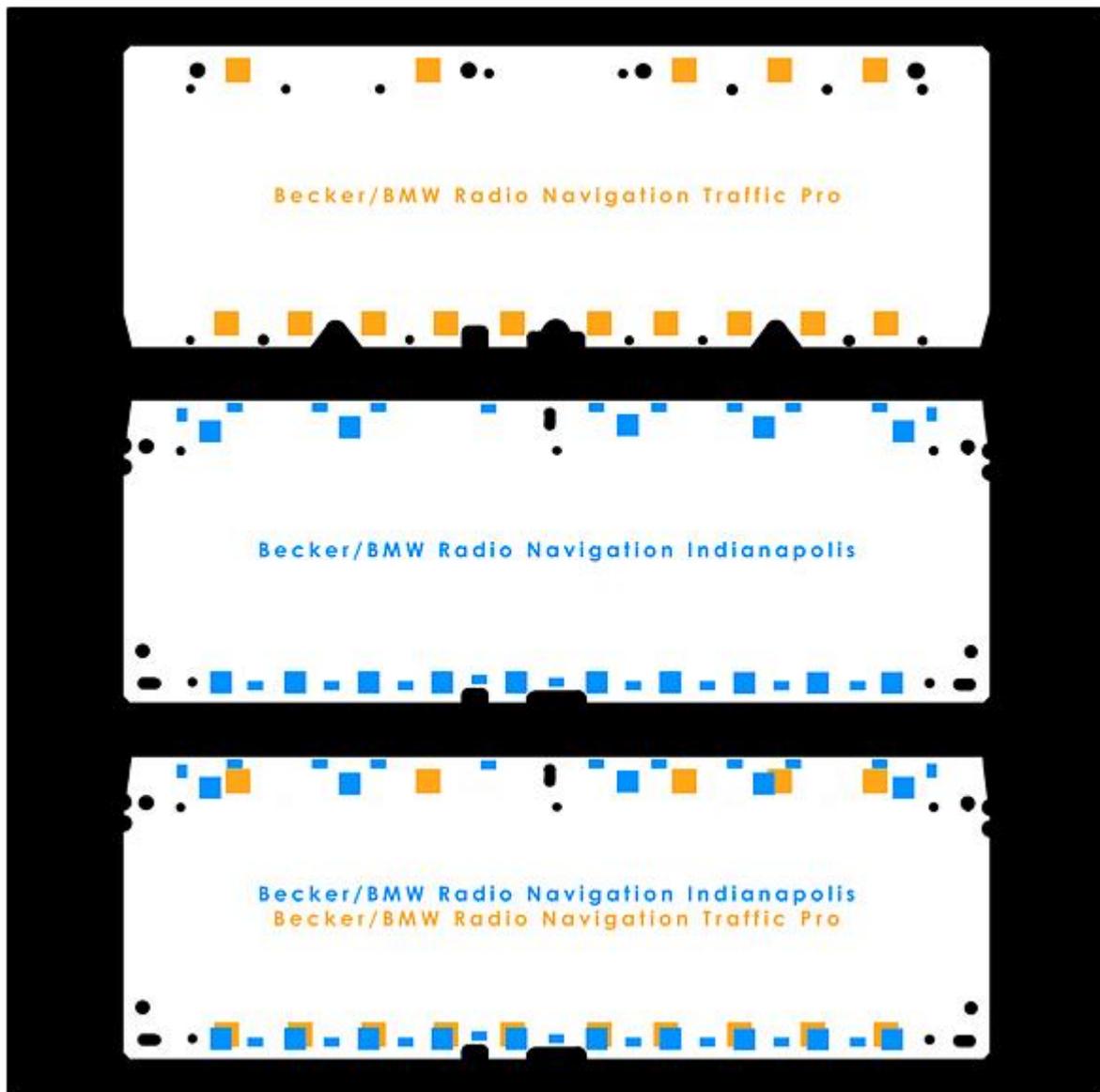


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Top left on the overview pictures you see the metal bracket that keeps the display firmly pushed against the PCB. Top right is the backlight diffuser. The Traffic Pro has an orange diffuser, but I don't really see the point of that because the orange color comes from the orange LEDs and not the diffuser. LEDs are monochromatic light sources. Working with color filters doesn't have much effect.

In the center and on the detail photographs you see the front side of the PCB with the display folded back so you can have a look at the backlight. The Traffic Pro uses much larger LEDs in the backlight. That explains why it's so bright. Because the display is folded back you look at the rear side of the LCD display. On the Traffic Pro the rear side is just as black as the front side (ignore my fingerprints), but on the Indianapolis it's white instead of blue. The reason for this is a semi transparent reflective layer on the rear of the Indianapolis display. This layer reflects incoming sunlight making the display readable even without a backlight. It's this layer that gives the typical grey color many LCD displays without or with dimmed backlight have. A negative display is more difficult to read without backlight than a positive, thus Becker opted to leave the reflective layer away to benefit from the maximum light output from the backlight. If the backlight is off the display is hard to read. But that's not an issue. The backlight is meant to be on.

Now we know the Traffic Pro hardware works on the Indianapolis, it's time to fit it in the Indianapolis' front. But... There are quite a few differences. The five buttons on top of the display are in different locations. The Indianapolis has LED illumination for each key while the Traffic Pro has four powerful LEDs (one in each corner). The light is distributed to the buttons by transparent plastic bars. The holes in the PCB are in different locations and the shape of the PCB differs a bit so it doesn't fit in the Indianapolis removable front .



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The picture above shows the main differences. The yellow and blue squares are the button contact pads from the Traffic Pro and Indianapolis respectively. The small blue rectangles are the LEDs of the Indianapolis' button illumination. The last image shows the Traffic Pro's key layout over the Indianapolis. Now you can clearly see the differences. There is some work on it... The shape of the PCB has to be altered slightly, several contact pads have to be relocated and the key illumination must be redone from scratch (we can use LEDs from the Indianapolis for this). The different locations of the holes is another problem, though. I don't dare to drill new ones. The PCB is made of at least 4 layers traces: There's no way to see whether or not there are traces below the surface. If it turns out you drilled through several traces in lower layers there's no way to fix it. We'll have to tackle this issue by changing the case, not the PCB.

Where the polarization filter swap from the [Becker/BMW Radio Navigation Indianapolis mod](#) was already risky in terms of damaging the unit, it should be very clear that this mod is even a step further. *Any warranty - if still on one of the units - will be void. The chance that you will ruin both the Traffic Pro and Indianapolis display unit should not be neglected and it's not even sure the final result will be satisfying!* Because of my urge for perfection this won't stop me, of course.

The mod

Making the Traffic Pro PCB fit in the rear half of the Indianapolis' case is not that hard. Just file the top left and top right sides a little bit. The front half of the case is for later.

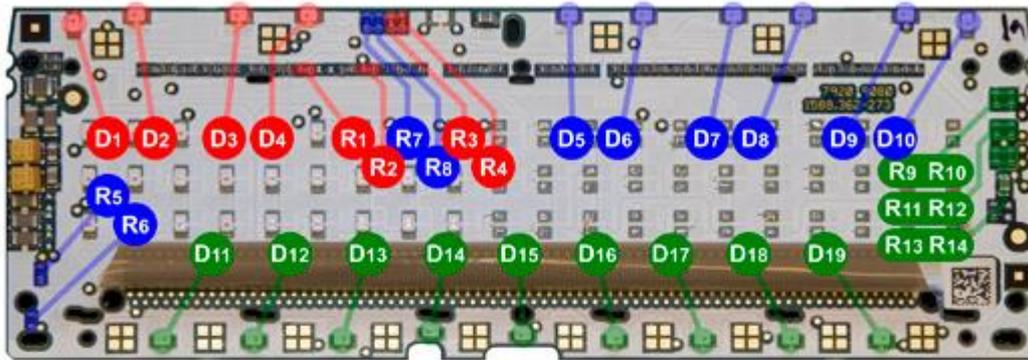
For the key illumination I'm going to use LEDs from the Indianapolis. Of course this will render the Indianapolis front useless. If you don't want to take this risk, you'll have to find LEDs elsewhere. But finding such small LEDs in the right color may prove to be difficult. If the mod fails you can always put the used LEDs back onto the Indianapolis PCB - assuming you didn't fry 'em of course.



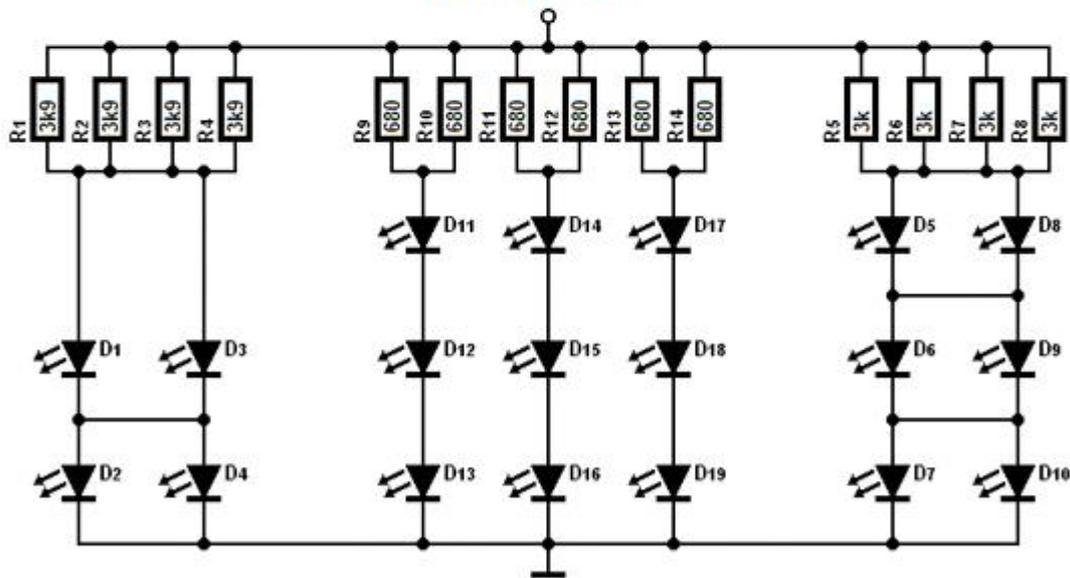
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If you are going to work with such tiny components it should be obvious you need very fine soldering equipment. Otherwise you are melting LEDs instead of soldering. On the picture above you see below the soldering iron from right to left a 3.2mm (0.13") "chisel" soldering tip (the standard choice for most soldering) and a 0.8mm (0.03") "point" soldering tip for finer work. On the soldering iron is a 0.2mm (0.008") "needle" soldering tip for very fine soldering jobs like this one. The LEDs are also fixated to the PCB with a small drop of glue, thus you'll have to use some force to get them of the PCB while desoldering.

As said earlier on the Traffic Pro uses only four LEDs for the key illumination - The Indianapolis uses 19! Thus it's not just relocating 4 LEDs. It's important all LEDs have the right brightness so it should be made well-considered. But why experiment if we already have the perfect example: The Indianapolis display unit. I used reverse engineering to find out the wiring schematic of the LEDs. The result is below:



Becker/BMW Radio Navigation Indianapolis
Key Illumination



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This network is powered by contact 11 (ground) and 12 (positive voltage) from the row of contacts on the rear side of the PCB. The voltage for the LEDs comes straight from the main radio unit itself. That is good news. This means the Traffic Pro PCB gets exactly the same voltage for the LEDs. I can rebuild the schematic from the Indianapolis 1:1 for the Traffic Pro.

The combinations of resistors and LEDs may appear a bit illogic at first, but there's a simple explanation. Assume a 12V power supply. The current through a single LED of the left group is:

$$I_{led} = (U_{batt} - U_{led1,3} - U_{led2,4}) / (R1 \parallel R2 \parallel R3 \parallel R4) / 2$$

U_{batt}: battery voltage

U_{led1,3}: voltage over LED 1 and 3

U_{led2,4}: voltage over LED 2 and 4

∥: parallel resistance

$$I_{led} = (12V - 2V - 2V) / (3900ohm \parallel 3900ohm \parallel 3900ohm \parallel 3900ohm) / 2 = 4mA$$

For the right group the current is:

$$I_{led} = (U_{batt} - U_{led5,8} - U_{led6,9} - U_{led7,10}) / (R5 || R6 || R7 || R8) / 2$$

$$I_{led} = (12V - 2V - 2V - 2V) / (3000ohm || 3000ohm || 3000ohm || 3000ohm) / 2 = 4mA$$

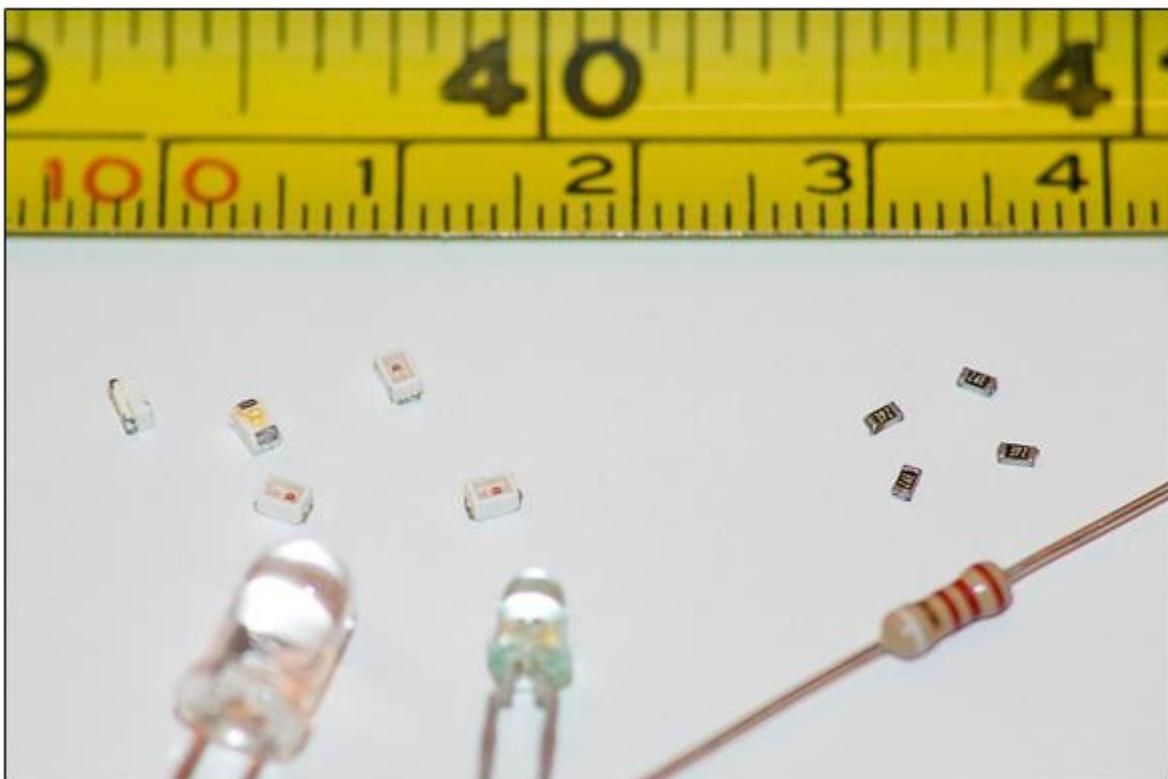
Exactly the same. Makes sense, not?

Now the middle group:

$$I_{led} = (U_{batt} - U_{led11} - U_{led12} - U_{led13}) / (R9 || R10)$$

$$I_{led} = (12V - 2V - 2V - 2V) / (680ohm || 680ohm) = 18mA$$

Whoops... Did we make a mistake? No! When we take a closer look at the mechanical design of the key illumination we notice the top row keys each have 2 LEDs directly beneath the key. The bottom row on the other hand only has LEDs beneath the edges of the keys. Thus they must shine a lot brighter to get the same level of key illumination. Hence the higher current.

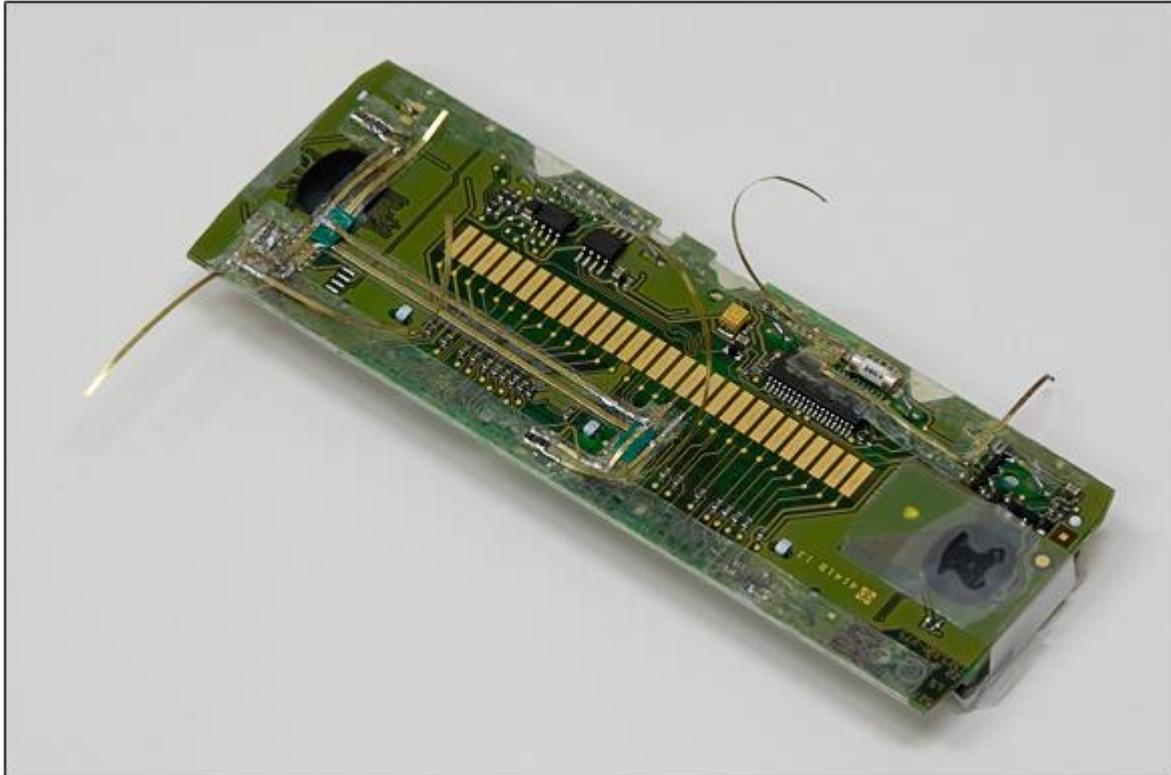


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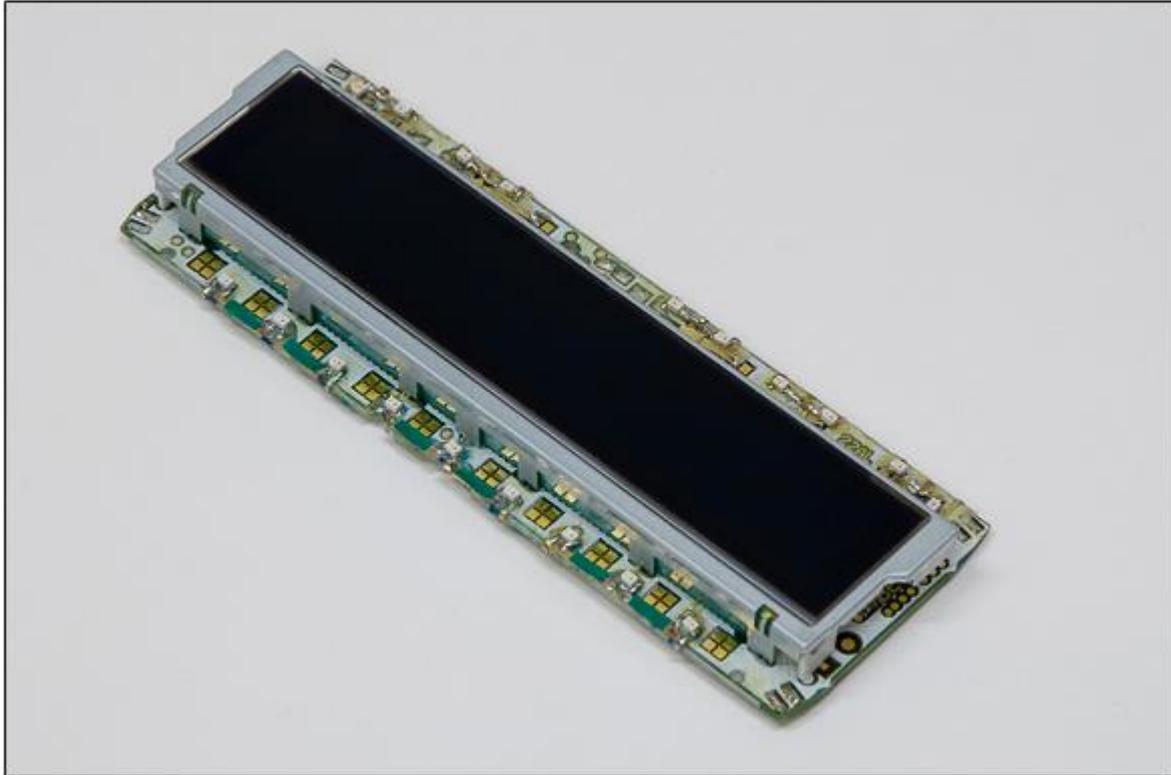
The upper half of the ruler is in inches - the lower half in centimeters. The tiny white blocks are the LEDs. For comparison, I put a 5mm (0.2") and 3mm (0.12") LED next to it. Did I already mention the LEDs are small? When you place the LEDs don't forget LEDs have an orientation for current. Placed in the wrong direction they will not work. For the LEDs from the Indianapolis display unit the small dark spot in the LED indicates the negative pole.

There's very little room in the display unit case for the wiring and realisation of my modifications. At most places less than 1 millimeter (0.04") in each direction! Maybe I'll have to modify the inside of case. Relatively large components like standard "through the hole" resistors won't fit at all. The easiest way is using the SMD resistors from the Indianapolis. If you thought the LEDs were small, wait until you see the resistors. These are less than half the size of the LEDs! On the picture above the small black blocks are the resistors. A standard 1/4W resistor is put next to it. I'm taking all parts from the Indianapolis display unit because I have no need for it anymore, but if you work carefully it can all be undone to make the Indianapolis front work again.

My idea is to glue the new wiring onto the Traffic Pro's PCB. It needs isolation first, though. I opted for 0.15mm (0.006") thick plastic foil glued onto the PCB over the places where new wiring will come. There are cut-outs for the current contact pads (the bottom row buttons re-use the Traffic Pro contact pads and the top row contact pads must remain accessible to connect the relocated contact pads to).



Here I just started laying the traces. I cut the traces from a 0.05mm (0.002") thick copper plate. When you connect two traces you have to take care not to melt the isolation foil. This may cause an unwanted short circuit with traces on the PCB. When you're wiring the unit you have to pay very good attention to the inside of the case. On many places the case touches the PCB. You can't put your traces there unless you modify the case carefully.



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The front side is ready. The LEDs are placed and the contact pads relocated. I had to redo the bottom row LEDs a few times. At first these looked like an easy job, but it turned out to be quite delicate to position correctly. If placed even slightly out of position the illumination of the buttons becomes inconsistent which is quite ugly. The top row buttons had to be modified. When you press the buttons they normally touch the PCB. But that's where I put traces. Thus I filed the rear sides of the buttons to match my modifications on the PCB. Especially the second button (TP) turned out to be a problem. There are a few components on the Traffic Pro PCB right where the button should be. In other words, the contact pad and LEDs are a tad higher on this location than for the other buttons. The button had close to no room left to be pressed. Carefully I sunk the rear of the button to make it operate normally like the other buttons.



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The rear side. Not my best soldering job, but it was far from a comfortable job. For the bottom row LEDs I didn't follow the schematic completely to lessen the amount of traces.

Now the PCB is done the case had to be modified. On some places the PCB became about 0.5mm (0.02") thicker due to my modifications. I tried to locate thicker parts in places with enough free space, but that wasn't always possible. All small changes, not worth making pictures of.

Testing

And then comes the moment... The moment of re-assembly and testing. In my testsetup a press on the "ON" button leads to a bright orange BMW logo on the display. Victory? Barely a second later the display goes dark. Panic...



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A closer look at the display reveals that there is text displayed. Difficult to read, the unit asks to enter the radio code. Did the backlight die? A short circuit or overload due to my modifications? It all seemed unlikely, especially because I could reproduce the problem by turning off the power for a while and retrying. The hardware is fine.



After entering the radio code, the Indianapolis appeared working normally - apart from the backlight. The key illumination remains dark too. Looking at the brightness setting in the options it struck me the unit displayed 31 (see picture above). The original Indianapolis goes from 0 to 8. So we turned down the brightness...



... and yes, there is the backlight. As soon as the brightness is within normal regions the backlight lights up as it should and the same goes for the key illumination. I'm not entirely sure what causes this. Maybe the Traffic Pro was adjustable between 0 and 31? It's of no importance, the unit works.



Somewhat unexpected my eye fell on a new option in the menu: "LCD". This option was not available on the Indianapolis. This option switches the display between positive and negative mode. A feature that was present on the Traffic Pro, but not on the Indianapolis. And it works! It's a bit strange the names are swapped. What the Becker calls positive is negative and vice versa. If Becker would have kept this option in the Indianapolis software I wouldn't have to go through all this.

And what does the result look like?

This is what the old mod looked like at maximum brightness (8):



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And this is what the new mod looks like at almost minimum brightness (2):



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The contrast ratio is clearly a lot better with the new mod. Thus the background is darker where it should be black. And the backlight can go a lot brighter which enhances readability in bright daylight. However, taking pictures of the unit at maximum brightness failed because the display is then a lot brighter than the key illumination. Either I got an almost yellow display on the picture (long exposure), or key illumination that was invisible (short exposure). The human eye is still far superior to a camera.

The biggest difference with the old mod is the blueish shine in daylight which is now completely gone. Even in very bright daylight the display looks black or a bit brownish at most. Getting rid of the blueish shine was the reason I began this mod and I succeeded very well by transplanting a Traffic Pro display unit into the Indianapolis. Only now the Indianapolis is truly worthy to be placed in the E31. That won't be for the coming months though, I'm afraid (the car is put away for its winter sleep), but as soon as I have pictures of the modified unit in the interior of my BMW I will post them.

A lot of time and effort was put into this mod. It's not given to everyone to perform a mod like this. Not because of the required technical knowledge (which is very limited), but the fact that you may very well turn an expensive and perfect working unit into garbage. But there's also hope for the less adventurous people who want to keep the stock appearance enhanced with modern features like mp3 support. A Blaupunkt/BMW Business CD (CD43) can easily be modernised with an iPod and DICE (which is even able to display ID3 information on the CD43 display with the R17 harness) or with a [Phatbox](#). Even bluetooth is possible...

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