Please note, this is an old document. We have developed a newer simplified kit with a bolt on manifold. The new kit does not require an electronic actuator and fitment is far easier see here: https://hdi-tuning.co.uk/ecu-remapping/unlocked-ecu-immobiliser-delete/TF035-Mitsu-Vacuum-210-Manifold-kit.html

1.6 HDI 90 or 110 Turbo and injector upgrade - TF035 Turbo

After finishing a few turbo upgrades on the 1.6 HDI engine I started to wonder if there was a better solution. Although a big turbo does offer great top end power, the spool can be too late to get good useable torque.

My quest for a better turbo upgrade began and after lots of research I decided to use the Mitsubishi TF035 turbo from the 2.0 177 BHP BMW engine. This turbo was obviously capable of 180 BHP quite easily, and when pushed on the BMW 2.0 engine offers over 200 BHP.

A major plus for this turbo was that it uses an electronic actuator to control the VNT rather than the old style of an open loop vacuum system. These can be troublesome after turbo rebuilds if the VNT has not been calibrated properly, also there is substantial delay between a corrective signal from the ECU and the VNT arm changing the pitch of the VNT geometry.

The TF035 turbo would offer precise control of the VNT with a much better response time. Another benefit would be that thanks to a fully electronic mechanism, a transplant of the same model of turbo would give the same results on another vehicle, hence I would be able to offer this remap to others without needing to carry out a week of development work to get the turbo pre-control settings perfected.

The aim of this project wasn't for all out peak horse power, because with that a large turbo is required and this will inevitably have a late spool. A late spool takes away all that low-down torque which makes a diesel car nice to drive. When looking at dyno plots, the useable power is the area beneath the power curve. A power curve with early torque will give a much wider useable power band than one that only peaks at the higher revs.

Parts required:

I've been very helpful here and tried to make a complete count of the main parts required. Yes, there will be a few pieces that I missed, and the parts required will probably be slightly different from car to car.

Part name	Purpose	Price	QTY	Total
Paddle clutch black Diamond	Clutch	£480.00	1	£480.00
12" Slim line fan	Cooling	£24.95	1	£24.95
63mm 90 mandrel bend	Exhaust	£13.00	3	£39.00
63mm 45 mandrel bend	Exhaust	£12.99	2	£25.98
2.5 inch stainless flexi 8"	Exhaust	£12.99	1	£12.99
BMW exhaust gasket part No.8513651	Exhaust	£8.50	1	£8.50
BMW turbo exhaust clamp 18308512137	Exhaust	£8.00	1	£8.00
Exhaust silencer	Exhaust	£36.50	1	£36.50
Exhaust silencer hanger	Exhaust	£10.00	1	£10.00

63mm 180 mandrel bend	Exhaust	£16.99	1	£16.99
10M Titanium Heat wrap	Exhaust	£8.54	1	£8.54
2.5" V Band grooved flange kit	Exhaust	£19.99	2	£39.98
60mm pipe with 80mm flare	Exhaust	£9.99	1	£9.99
Stainless Steel manifold adaptor with machined flanges	Exhaust manifold adaptor	£130.00	1	£130.00
0445110297 injectors	Injectors	£130.00	1	£130.00
76mm T piece	Intake pipe work	£21.07	1	£21.07
57mm 90 Silicone	Intake pipe work	£15.95	2	£31.90
57mm Aluminium joiner short	Intake pipe work	£7.64	1	£7.64
300mm 57mm alloy pipe	Intake pipe work	£6.99	1	£6.99
Plug for oil breather 30680774 1336611	Intake pipe work	£7.99	1	£7.99
59-63mm mikalor clamp	Intake pipe work	£2.10	4	£8.40
85mm Jubilee clamp	Intake pipe work	£2.56	2	£5.12
Ramair air filter 76mm	Intake pipe work	£24.99	1	£24.99
30-40 mm jubilee clamp	Intake pipe work	£1.46	10	£14.60
76 to 51mm silicone 90	Intercooler	£12.88	1	£12.88
51mm 45 Silicone	Intercooler	£9.00	2	£18.00
57mm Aluminium 135 bend	Intercooler	£10.94	1	£10.94
85 to 90mm Mikalor clamp	Intercooler	£3.10	2	£6.20
63-68 mm mikalor clamp	Intercooler	£2.25	6	£13.50
700x300x75 twin pass intercooler	Intercooler	£150.00	1	£150.00
51mm stainless steel 45 bend long	Intercooler Air doser	£13.35	2	£26.70
76 to 57mm silicone 90	Intercooler and turbo inlet	£13.93	2	£27.86
3.1 Bar MAP sensor Part No. 9649396580	MAP sensor	£30.00	1	£30.00
16mm silicon 90 bend	Oil drain	£9.86	1	£9.86
16mm aluminium tubing x 1 meter	Oil drain	£3.60	1	£3.60
16mm silicone oil pipe	Oil drain	£18.75	1	£18.75
thick copper banjo washer	Oil feed	£1.00	6	£6.00
AN-3 M12 45 Banjo	Oil feed	£9.59	1	£9.59
AN-3 stainless braided teflon hose	Oil feed	£5.99	1	£5.99
AN-3 M12 90 Banjo	Oil feed	£10.99	1	£10.99
90 32>25 silicone reducer	Rad hose relocation	£11.65	1	£11.65
Aluminium Joiner 25mm x 300	Rad hose relocation	£3.62	1	£3.62
25mm Silicone Hose 1 meter	Rad hose relocation	£14.95	1	£14.95
25mm aluminium 90 bend	Rad hose relocation and breather	£9.10	3	£27.30
TF035HL6b-13TB-VG Turbo charger 724779	Turbo	£144.95	1	£144.95
		Total	**79**	**£1,673.45**

<u>Injectors + MAP sensor</u>

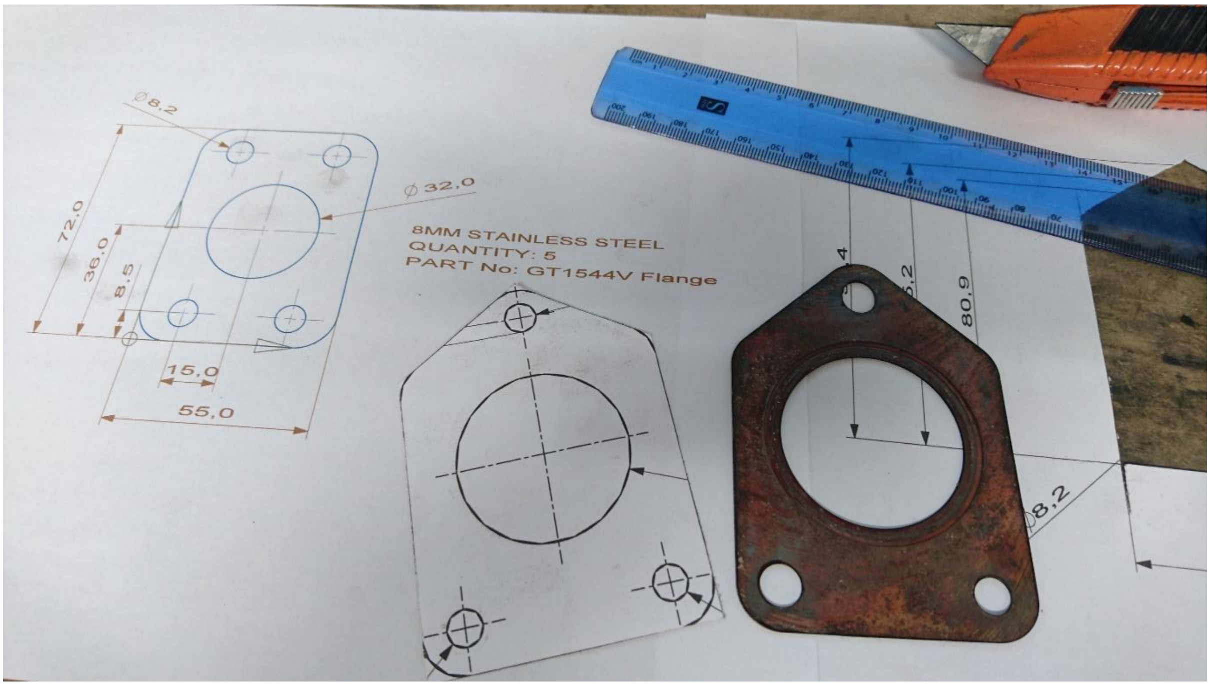
So, let's get the easy parts out the way first, the injectors need to be upgraded to 0445110297, these are the highest flowing injectors available from a 1.6 110 16V engine. Generally, these come from the later models from around 2008.

The MAP sensor on the standard setup reads only to 2.5 bar (absolute), a replacement 3.1 bar sensor can be used. The part number for this is XXXXXXXXXXXX

The plug is almost the same, but you'll need to scrape the side off to remove the slot which prevents it going to the sensor. For both the MAP sensor and the injectors it's important that you don't use the vehicle without having them calibrated in to the ECU through a remap.

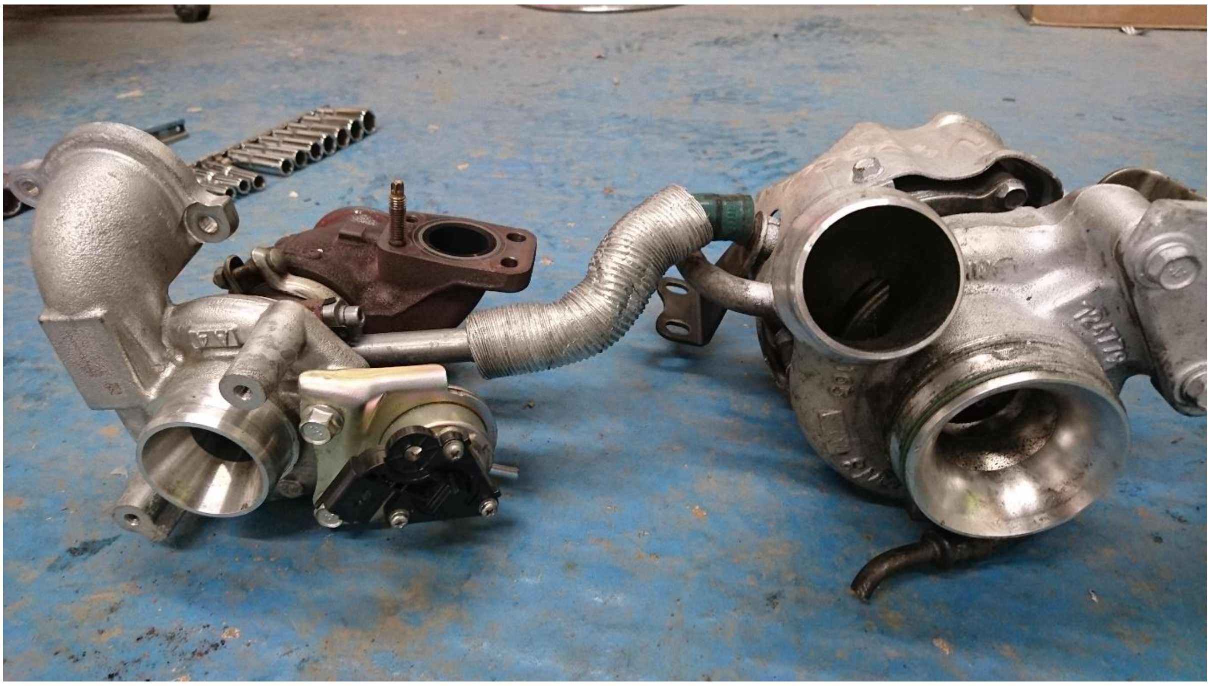
Manifold adaptor

The first step to getting the turbo mounted was to design a set of flanges so that a manifold adaptor could be mocked up to hold the turbo in place. Here I drew up the flanges and sent them to be laser cut, much faster and cheaper than CNC machining and they were ready within 24 hours.



I found that the 110-manifold looked a little bigger than the 90 manifold so I decided to swap this over. The outlet port wasn't really that round so I used the new flange as a template and then a Dremel to machine it out a bit. I did the same on the exhaust ports to make them as big as possible and increase flow.

The next step was to find a way to fit the turbo under the bonnet. At first there was no chance of it fitting as it wouldn't fit between the engine and the radiator fan. Here is a comparison of the TF035 against a TD02 (same size as the TD025).



The radiator fan had to go, and the radiator needed to be moved back. This is a photo of the radiator housing for a Peugeot 207, most models use a similar setup and there is a large gap between the radiator and the air con radiator. Here I used a cutting disc to take off as much as I could.

Two holes can be drilled in the base and then the radiator slotted back in, this holds it perfectly tight and gives much more room. The top can be held in using a couple of bolts through the plastic. Ignore the dents on the radiator, this was from the initial attempts to fit the turbo in, clearly it wasn’t going to happen.

After a mock-up of the turbo the next issue became apparent. It was going to be very challenging to fit between the oil cooler, alternator and the air conditioning pump. Losing the AC was not an option. The air conditioning pipes were right where the compressor outlet needed to be. Luckily the AC pipes are very malleable, and if you’re very careful you can bend them out the way without cracking or breaking the seals anywhere. If you do this use full facial protection just in case you break it and the gasses/oil come out at you. Here a large adjustable spanner around the pipe worked great.

After making up a jig I could make a manifold adaptor and get the turbo in place. Here’s one I manufactured myself using a MiG welder and very thick butt weld stainless fittings. Due to distortion after welding I needed to take this to a friend’s machine shop to get the flanges perfectly flat so that they would make a nice seal. Use a new Peugeot gasket on one side and the BMW gasket on the other side to create a good seal.

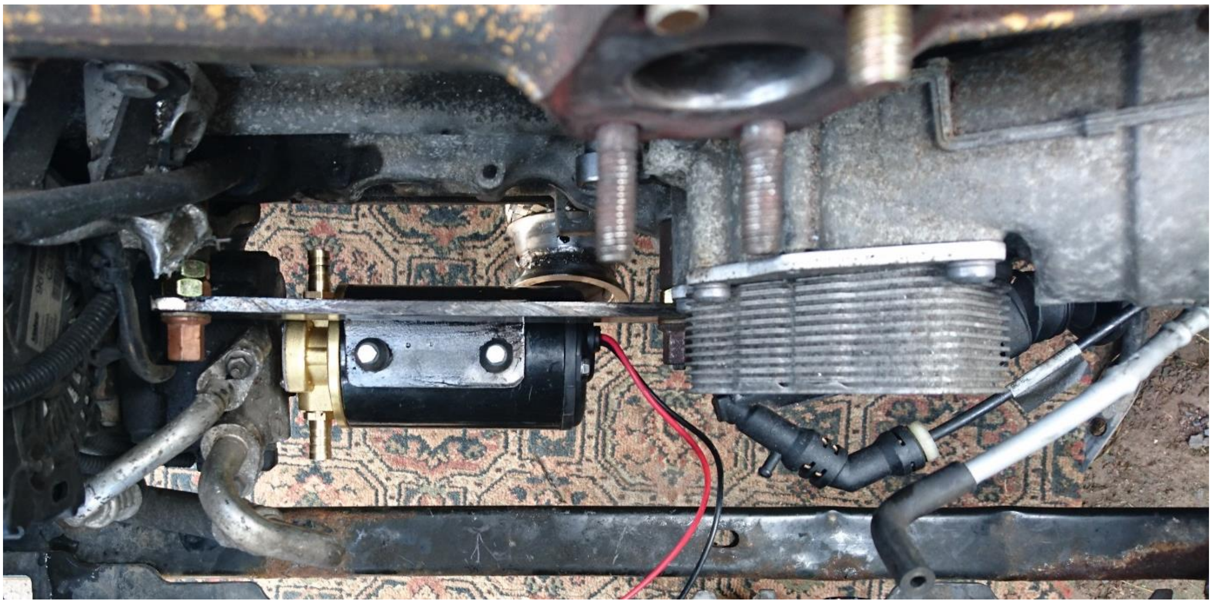
Oil feed and Oil drain

With the turbo in place the next challenge was the oil feed and the oil drain. The oil feed was relatively easy after sourcing the correct parts. Here I used AN3 braided PTFE hose with an M12 45-degree banjo at the turbo side, and a M12 90-degree banjo going to the outlet from the oil pump.

The fittings come with an olive and a nut, after contacting the supplier they confirmed that the stainless braid must overlap the olive. Although it felt odd as the nut would not go all the way along the thread, I can confirm that this has worked well with no leaks. I would advise getting a hose made with crimped fittings and then it can't fail.

The original banjo bolts were re-used, but due to the thinner M12 banjo different copper washers were required. It's important that the thread can tighten all the way without hitting the shank. It's also important that the eye on the bolt is in the middle of the banjo for best flow. Two thick original style washers must be used on one side, and then one original washer and one thin copper washer on the back side which comes with the new banjos. As the washers are being stacked don't try to re-use your old ones as they won't mate together properly and you'll end up with an oil leak.

The oil drain of the new turbo is now too low to go in to the original drain hole. This left two options, drill the sump, or use an oil scavenge pump. Initially the scavenge pump seemed like a great idea, however once eventually finding place to mount it I removed it. The scavenge pump is just too unreliable for me and I wouldn't be comfortable with this complexity, especially when it has a thermal cut out after around an hour of use.



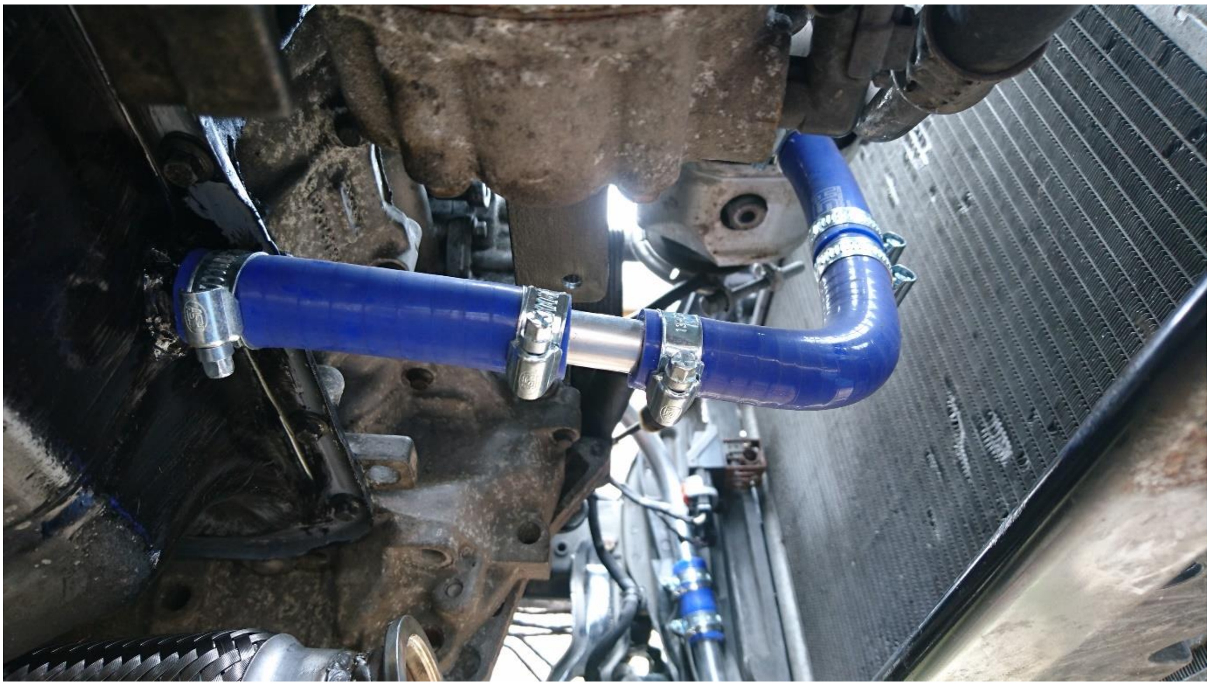
After realising that a new sump pan would cost only £30 if my next plan didn't work I took the sump straight off. I saved the oil I drained out and poured it in to the sump. The oil level with 4.5 litres came right to the top of the sump. As the turbo drain can't have any restrictions this at first worried me, but I quickly realised that with the engine running most of the oil would be pumped around the engine.

Next, I welded a 16mm tube on to the sump (sump is made of galvanised mild steel) and then drilled a hole through the centre. The tube needs to be as high as possible whilst still letting you get access to weld around it. Obviously put it between two bolt holes and not in line with the sump pan bolts. I put some black Hammerite over the top to prevent rust around the weld.

This gravity drain solution was much better and 100% reliable compared to a complex electrical pump. As predicted the oil level when running is not high enough to block the tube so this works perfectly.

The drain from the original turbo conveniently fits on to this turbo. Screw this on with a new gasket, and then run the 16mm silicone tube down. It's best to use silicone hose that's designed for oil for the turbo outlet as this will be quite hot initially.

Join the silicone with a piece of 16mm tubing and then run it to a 16mm 90 bend. I chose to make this slightly short to keep the bend uphill rather than with a dip at the bottom which would fill with oil.



Exhaust system

Now the turbo is attached to the engine you can start working on the exhaust system. An 80mm flared 63mm tube fits perfectly on to the BMW turbo. I welded this to a 180 mandrel bend and then another 90 bend to go around the side of the sump. With the correct BMW gasket and clamp this fits reliably on to the turbine outlet without any exhaust leaks.

Here’s the down pipe and my complete exhaust system.

So, I'm not a welding specialist and certainly not a fabricator, but once I started working on this and bought a new welder I decided to do it all myself. In hind sight, £300 for materials and the labour involved by an exhaust shop isn't such a bad deal, just pay somebody to do it with one complete pipe and no welds.

For the exhaust, I used 63mm stainless tubing all the way along, with a stainless flexi at the front. The brackets I used were an exhaust repair kit from eBay. This gave me the hangars and the rubber mounts which was very helpful.

The backbox is a simple 63mm straight through silencer. I used a 2.5" V band clamp after the down pipe, also another before the silencer so that the exhaust could be dismantled without taking the car apart beneath.

With the exhaust system completed I chose to mount a support bracket under the turbo. This used a thick piece of steel onto the bolt on the bottom of the turbo. This can then mount to the bolts where the DPF canister would normally be held. As I had made a bracket for the oil pump which was no longer being used, I mounted my bracket on to this. A bracket it important as over time, the heat and vibration and the mass of the turbo will result in a cracked manifold or a crack on the manifold adaptor.

<u>Intercooler and turbo pipe work</u>

The car already had an uprated intercooler, but I had a much bigger one taking up space in my workshop. In my opinion, a big intercooler makes hardly any difference to turbo lag, but it does drop-down intake temperatures. With this 700x300 intercooler the intake temperatures didn't go past 37 degrees with 2.9 bar boost sat on a dyno with minimal air flow. This really shows how well it works. I've seen the stock cooler have intake temps of over 100 degrees on the dyno before.

There are companies selling intercoolers for upwards of £300, this really isn't required because there are no great changes in technology which can improve an intercooler. It's best to focus on a big intercooler rather than an expensive smaller intercooler as this will always give lower intake temperatures. A twin pass intercooler offers greater efficiency and is much easier to fit as the inlet and outlet will be in the correct place.

Surprisingly this monster intercooler fits beneath the bumper on the 207 without any cutting required. Mounting brackets can be welded directly on to the steel bumper support beam. Here I sprayed with some primer after welding but painted black afterwards so it would not show through the bumper.

The lower outlet requires a 76 to 51mm 90 bend. A 45-degree stainless 51mm tube can now be used to weld a mounting boss for the MAP sensor and the temperature sensor. The air doser valves can be removed as they are very small and restrictive.

The top inlet required a 76 to 57mm 90 bend followed by a 135-degree 57mm alloy join with flared ends. A silicone 57mm 90 bend must now be cut to fit over the turbo outlet.

Although the end of the turbo outlet is 51mm, there is no way to secure a pipe on to this without finding the original BMW pipe with a tight radius and a locking clip. Flexible corrugated hose was tested, and this did not last long as the jubilee clamps wore through the hose, although the hose did not pop off.

This next step is the only part of the build that I couldn’t find a better solution to, however it works very well. Cut a 90 57mm silicon near to the bend. Test to make sure it fits between the turbo and the AC pipes.

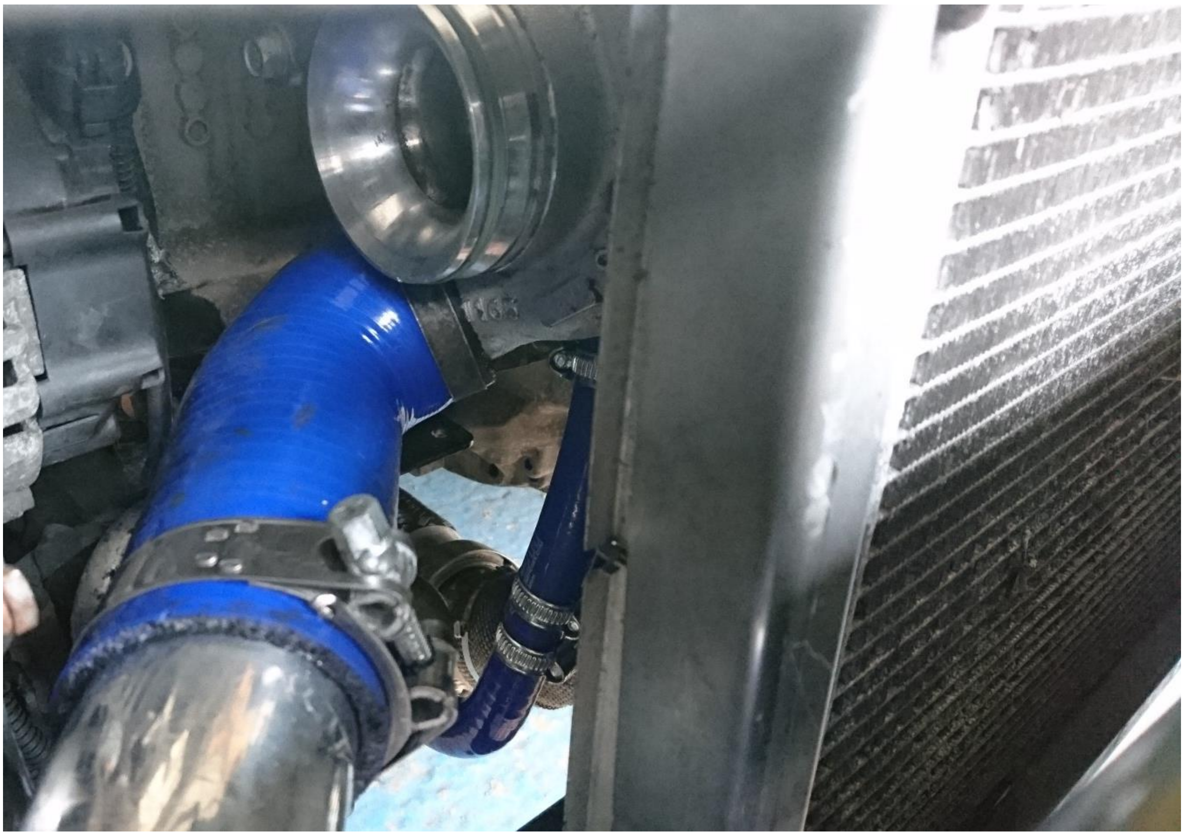
Smear some sump gasket sealant around the inside of the hose, and then push it all the way over the turbo outlet.

Use a jubilee clamp tightened over the opposite side of the flange on the turbo so that the pipe can never pop off. Let the silicone dry before testing the vehicle, you now have a very permanent seal on this hose that will not affect reliability.

Although this may at first seem like a ‘bodge’ I’ve glued boost hoses before and found it works very very well. In fact, if you take the hose clamp off you’ll need to cut the silicone hose off. It will hold very well and there is no risk of a small boost leak as the silicone fills the gaps perfectly.

Here’s how it fits next to the AC pump, tight, but no interference with the pipes. I glued both ends of this pipe as it would be very difficult to fix if it were to pop off at any point. I recommend gluing all your boost pipes with silicone gasket sealant once your build is finalised, it just adds that extra reliability as over time the clamps stretch and pipes will pop off.

If you can source the BMW hose with a sharp 90 bend and a clip to go on to this turbo then this would obviously be a better solution.



The turbo inlet fits a 76mm 90 hose which can be reduced to a 57mm hose. Run the pipe along the front of the engine bay over to a free flow air filter. There is no need to run a MAF on this build as we can calculate air mass through the ECU using the boost pressure reading, air temperature and the volumetric efficiency of the engine. The standard MAF will be maxed out at anything past 145 BHP so it doesn’t serve much of a purpose on a build like this.

The oil breather can be directed back in to the inlet. I’m not a fan of catch tanks as they spew out oil fumes and usually fill up with oil and require maintenance. Using the ford TDCI oil breather clip you can easily make your own breather pipe work.

Cooling

Due to the exhaust down pipe the radiator pipe needs to be re-routed around the engine bay, this is easy to do with some silicone hose.

A slim line fan needs to be fitted on the outside of the air con rad behind the bumper support beam and on the inside of the radiator. Once this is wired in, test using the PP2000 actuator commands to ensure that the front fan is sucking air in to the radiator and the back fan is blowing air through.

I found that I could program the fan to come in at a lower temperature in the software and this can then keep temperatures low before they get past 90 degrees. It's better to have too much cooling than to risk overheating in traffic on a hot day.

Wiring to the turbo actuator

This may seem complicated at first but is relatively simple to do. First you need to find the live feed and the PWM ground from your turbo electro valve. On the PSA vehicles, it's bolted to the back of the engine, on the Fords it's usually at the front right of the engine bay near the ECU.

The turbo electro valve used a permanent 12V feed and then the ground is pulse width modulated by the ECU.

To find the live, connect a multimeter to ground on your battery, and then test both pins to find which is +12v. This makes the remaining pin PWM.

On the TF035 turbo there are a few more pins than we require. Two of them are for a position sensor feedback system which we don't have the option for in this ECU.

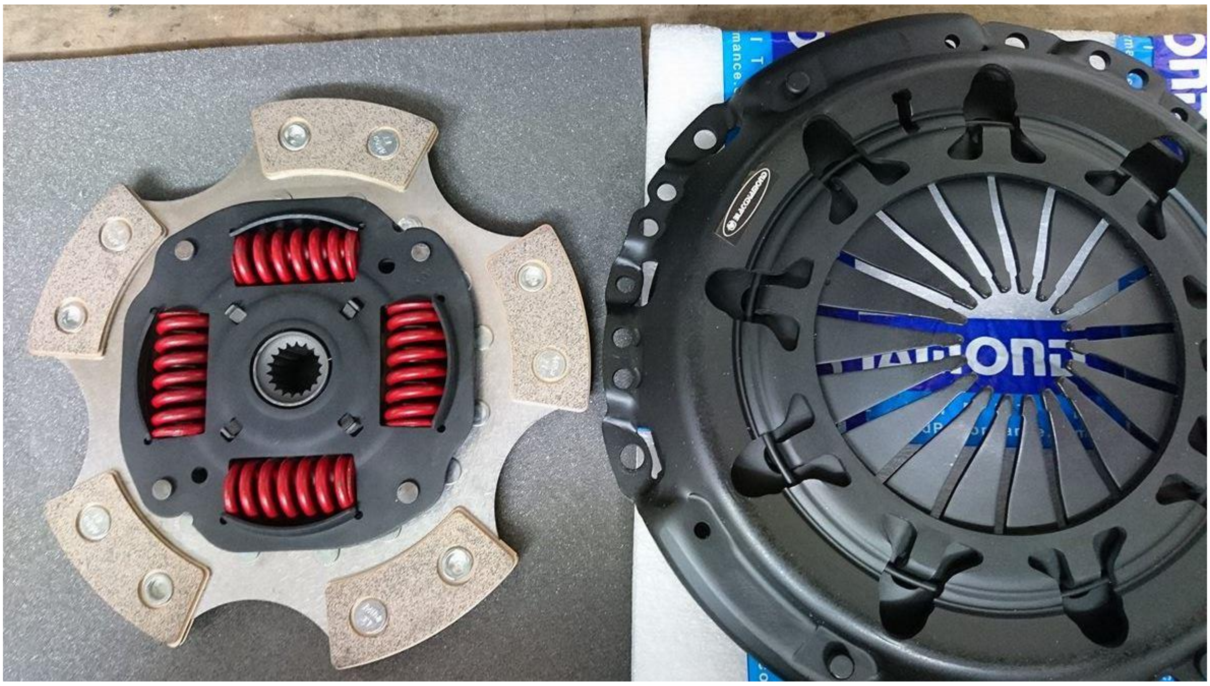
The Hella actuator requires +12V, GND, and PWM. Run a wire from the battery GND terminal to the actuator, and then the other two wires from the original turbo electro valve wiring.

Like the injectors and the MAP sensor, this is another part which won't work until the ECU has been remapped. The PWM frequencies and voltages are different and these need to be set in the ECU.

Clutch

A Black diamond ceramic paddle clutch was fitted to the solid flywheel. You can get the solid flywheel from the 90 models and the 75 PS vans. The 110 models come with a dual mass flywheel which will not handle this amount of torque.

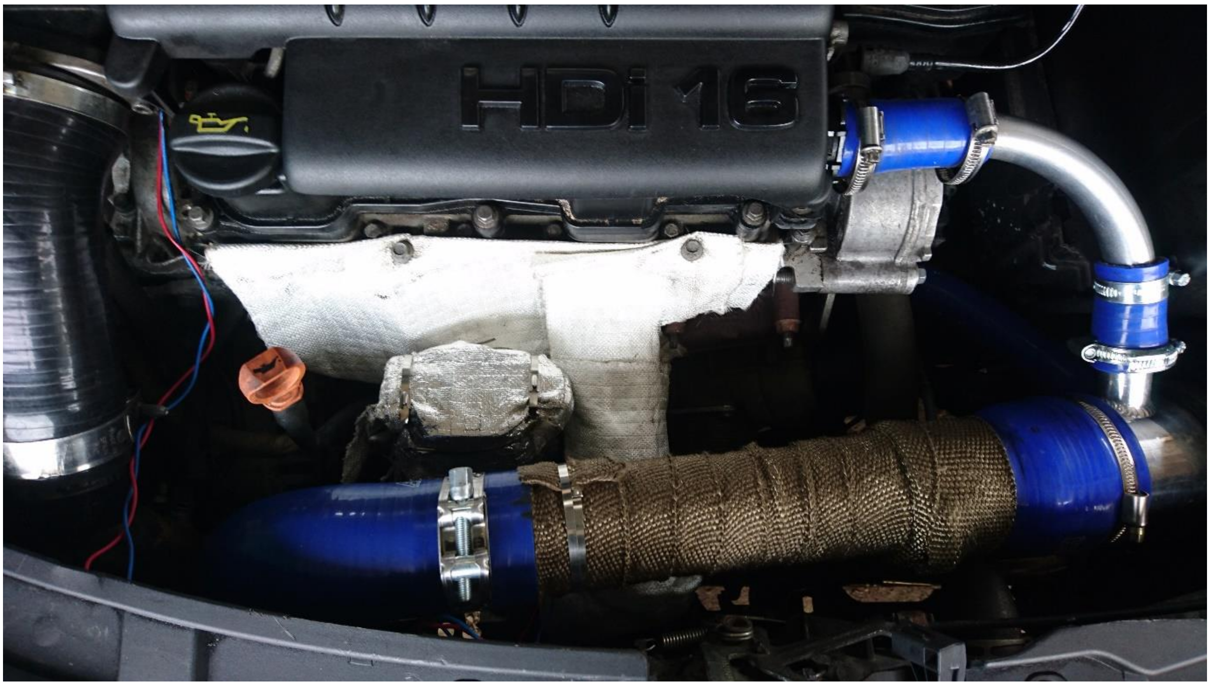
This drives very well, although is does need to warm up before it will hold the full torque. On a normal journey you'll heat it up through a few pull aways whilst warming up the engine anyway.



Heat wrap

Heat wrap the actuator for the turbo. Although it is made of a thermo plastic, it could still be damaged by heat from the exhaust manifold. So far, I've found that even after very heavy driving the actuator does not experience any problems due to heat, so a bit of heat wrap does work very well. Make sure your heat wrap doesn't interfere with the VNT actuator arm.

The exhaust manifold and the turbo need to be heat wrapped to prevent heat soak to the radiator which in turn would raise engine temperatures. The heat wrap can be bolted to the original tin heat shield bolts to hold it in place.



Here's the down pipe after wrapping with titanium heat wrap. A tip here is not to use the cheap metal cable ties, but buy a couple of drive shaft clamps. These hold the heat wrap on well and don't come loose. Another tip is not to rub this heat wrap all over your skin, it's VERY itchy stuff.

Remapping and development

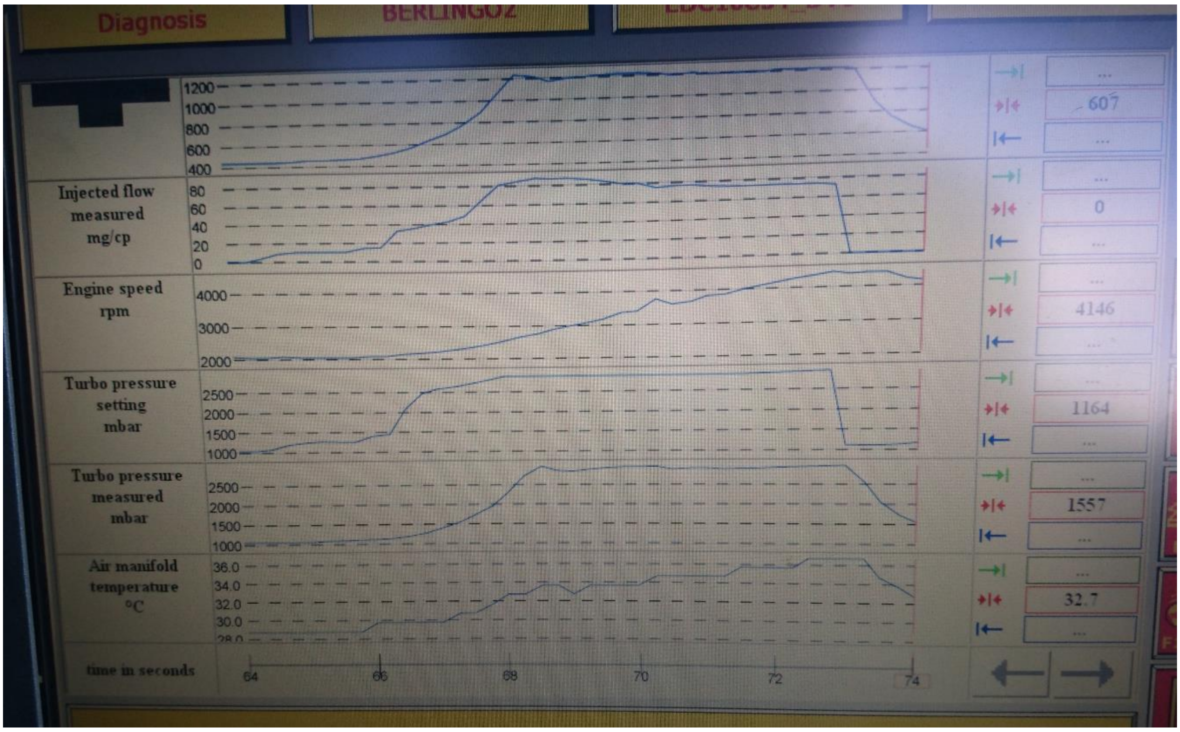
Now with all the hard work done, the tuning fun could begin. From the first test drive, I was impressed by the spool of the turbo and at that point I had not even began to optimise it.

Numerous tests were made to calibrate the VNT settings to get the turbo to boost as early as possible whilst minimising any boost spikes and keeping boost levels strong and stable.

The screen shot below shows just how stable the boost pressure was after lots of fine tuning. This was tested on a 3rd gear pull at full throttle. Most tuners don't understand how to do this and you'll get a big boost spike followed by a big drop in power. Here I avoid a boost spike which could blow the turbo and I avoid a dip in power afterwards by an over powerful PID loop. This is what separates the real tuners from the beginners who have little understanding of the complex control loops and how they integrate.

The logs below show air mass, injected fuel quantity, engine speed, boost pressure set point, boost pressure measured and intake temperature.

The slight spike in engine speed was due to a small third gear wheel spin (on a dry road surface).



After around a week of work on this, the turbo was performing very well. Now the next hard part began. Fine tuning the fuelling, injection timing and fuel pressure.

As this was running MAF-less I would use readings from the MAP sensor to calculate air mass available. The MAP pressure reading can be multiplied by the cylinder volume, the density of air, the volumetric efficiency of the engine and then divided by atmospheric pressure. With these values, the ECU could then calculate how much fuel would be allowed through the 'Lambda' maps to prevent smoke.

Results

This turbo offered great low-down torque, and the initial dyno results showed 278.5 lb.ft 378 Nm of torque and 198.3 BHP.

After lots of driving I am very happy with the way this drives. It has much better spool than a gt1544v hybrid with a 52mm compressor wheel and much better spool than the GT1749V and GT052V I've worked on.