VP37 EDC15VM+ TDI remap guide

or: take the long way home

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Disclaimer

This guide is for informative purposes only – all changes you make to your ECU software based on it are your own sole responsibility!

Introduction

This is a guide to help you understand how to properly remap a VEP TDI – it's a work in progress, should you find any errors or want to contribute something, please post in the thread below or contact me via PN at ecuconnections.com – my nickname is nexus665.

For completeness' sake, I've opted to include a lot of things that may at first not seem relevant. Bear with me, all will become clearer as we go along.

The most recent version of this guide can be downloaded from:

http://www.ecuconnections.com/forum/viewtopic.php?f=41&t=18159

Preface

A while ago, I became interested in remapping cars, mainly because I had had mine remapped, but had been having trouble with it, thinking "how hard can it be?" – well, as it turns out, quite difficult!

The main problem in remapping cars is knowing enough about what you are doing, really understanding and not just decalibrating things. You can never have too much knowledge about your tuning target's specs, be they hardware or software.

With this in mind, be aware that remapping cars is not a skill you just acquire in a short time. It takes a lot of time and a really big amount of dedication to do it right. Also, it won't ever be cheaper (in time or money spent) than a remap you can buy – but you'll have gained lots of knowledge in the process.

Always be aware that you can easily kill your engine if you don't know what you're doing – so always try and find out as much as you can before actually touching anything! Be sure to confirm your results and do log runs as well as use a boost gauge with warning function, especially on powerful setups. It can save you a lot of trouble and money…use common sense!

Another thing to note is that claims of superior gas mileage via tuning are pretty much useless – only the driver's right foot determines fuel usage, so rather adjust your driving style than get "eco-tuning"! Although it is possible to tune for economy a little bit by playing with SOI, you will never realize as much mileage gain as with driving in a more economical way.

So let’s get to the good stuff!

Chapter 1 – Planning

Get an original file

This is one of the most important steps – and also the first for any remapping purposes: you need to download the original file containing all maps from your car's ECU or download a copy of the same file from online sources, if available.

The original file this guide is based on is downloadable here:

http://www.ecuconnections.com/forum/viewtopic.php?f=41&t=18159

It's a MY 2002 Golf 4 TDI ALH (90hp/66kW) with software revision 360773.

Damos / A2L Files

Many people talk about these files, but it seems not everyone really knows what they do or how they work.

When car manufacturers first started using electronic control units for their cars, they needed a standard to exchange information with ECU manufacturers/developers about which maps control what. One of these was the DAMOS format. Inside these files, all existing map addresses, their names and conversion factors are noted, often along with formulas for their content.

Another standard that appeared later is the A2L standard – WinOLS and other map editors can work with these files, as well.

However, hardly any of the files people call "Damos" Files really are in DAMOS format – mostly, they're WinOLS project files that you can load and look at (.ols files), because these also contain the binary they are made for.

This tells us something very important: you need one that fits your ECU **EXACTLY**! For example, there is an Audi A4 VP37 "Damos" that's widely available, which is actually a WinOLS project containing a binary. **It contains all of the information you need to tune other VP37 cars, but it does NOT contain the correct addresses unless you have the exact same binary/software revision!**

Often, even if a DAMOS/A2L file is for your exact software revision, it will not have exact addresses, but rather offsets that you need to compare with your binary. This means that the addresses in the file need a starting address (offset) to work correctly.

However, even if the file is not for your exact software revision, you can use the information contained in it to search for the same **patterns** in your own binary.

This is an important skill, whether you're comparing maps from other cars or manually defining them – recognizing patterns and trends and applying them to your work.

Where do you want to go today?

As a first step, figure out your planned performance and what hardware mods you will need to reach it (if any). Meaning, figure out what kind of remap you want to do – a "Stage 1" with only software changes, a "Stage 2" with small hardware changes or a "Stage 3" with large hardware changes for extreme performance. For this, you'll need to know your stock hardware's limits. It helps to look at similar cars or the available engine options for your model for better reference.

Comparison – ALH 90hp/210Nm stock 1.9l VP37 TDI (not exact)

Stage 1	Stage 2	Stage 3
120hp/270Nm	**150hp/320+Nm**	**180-2xxhp/350+Nm**
Software only	plus larger injectors, upgraded clutch, no EGR, de-cat, single mass flywheel	plus upgraded turbo, intercooler, pump plunger, exhaust, downpipe, 6-gear conversion, extra fuel pump…

It all depends on your goals and your budget. It doesn't pay to overtax your hardware – rather be conservative in your power figures and have your car work.

What can my stock hardware take?

This is a bit tougher to answer, but I'll try to illustrate based on my own car.

Transmission

The stock ALH is equipped with an 02J 5-speed manual gearbox rated for 250Nm of constant torque. Its maximum stock torque is 210Nm, meaning the stock map is well under the transmission's rated performance. Above about 270Nm of torque, you'll need an uprated clutch and a single mass flywheel.

Now, people have managed to break this transmission with stock power – others have managed over 400Nm without killing it for quite a long time / lots of kilometers, even in drag use. Still, it'll break eventually if you keep abusing it, so keep a spare one if you go nuts on power…

Again, it all depends on your driving style and on the condition of your hardware. Be conservative with torque on 02J 5-speed gearboxes – especially below 2k RPM. For extreme power and torque, consider upgrading to a 6-speed gearbox or having your 5-speed box reinforced. A limited slip diff would also help get all that power on the road.

The 6-speed manual gearboxes and flywheels are rated for 350Nm of torque and can take a little bit more than that, as well, about 380Nm – above this, you'll have to look at uprated clutches and a single mass flywheel. You'll need gearbox, clutch, starter motor, flywheel, gear lever etc.

Clutch/Flywheel

The stock clutch will not hold much more than 270-280Nm of torque, depending on its condition it may even hold less. Same goes for the stock DMF (dual mass flywheel) – it starts to block (hit the end stop on its springs) at around 275-280Nm, as well. Be careful with your DMF, even new ones can be ruined very quickly by a few WOT accelerations outside their torque envelope…and they run a pretty penny!

Consider upgrading your clutch to a Sachs Race Engineering or a Spec clutch, for example, coupled with a single mass flywheel. This combination is good for a lot of torque, more than the gearbox can take…but it does bite! No comparison to the soggy stock clutch – oh, and start exercising your left leg, you'll need it for a change. More holding power wants to be operated with more power, as well.

Caveat: on 5-speed transmissions, a single mass flywheel is audible when idling – sounds as if something's wrong with your engine, clacks a bit – or rather, sounds like an old Diesel did…those didn't have dual mass flywheels, either. It's not that bad on a 5-speed box, but on 6-speed boxes it's very defined and loud – be aware of this.

The DMF can actually take more than the rated limit, but not at low rpm. The reason for this is that diesel engines have pretty harsh torque changes during their combustion phase, which the DMF is supposed to dampen, and stock diesels usually have their highest torque at low rpm. At higher rpm, the engine runs a lot more smoothly, meaning the DMF springs do not have to dampen as much peak load at the same torque and can withstand more total torque. Take care not to overdo things below 2500-3000 rpm.

Turbo

There are quite a few options to choose from when upgrading your turbo on an ALH – for example:

VNT15/GT1749V (90hp VEP original) – can do about 1.2-1.25 bar above ambient safely but limit it at high rpms!

GT1749VA (130hp PD original) – about 1.5 bar

GT1749VB (150hp PD original) – about 1.7 bar

GT1752/56 hybrid – about 1.8-2.1 bar, depending

GT20/GT22 or hybrid – over 2 bar

These are listed from weakest to strongest, all values are meant as approximate maximum safe sustained boost even at higher ambient temperatures. The VNT15/GT17s will fit without any or with only very minor modifications due to clips vs. no clips. Basically, you'll need to figure out whether your model has a turbo with welded-on exhaust manifold or whether it has a separate one and shop based on this. You can usually rotate the housing to make the openings point where you need them to if necessary – but never disassemble the shaft/wheels! Your turbo will need to be rebalanced if you do or it will kill itself in short order if you run it anyway and put load on it.

Be wary of hybrid turbos if you don't know where they came from and whether they were balanced. Lots of shops sell upgrade wheels and parts, but without balancing – and often some precision machining – it's not going to work. Ask for a balancing protocol when ordering an assembled hybrid turbo – a professional shop will have this on request. Also, many hybrid GT17 turbos are prone to surging and pumping because of inferior turbine geometry, again, be careful what you pay for.

The GT20/22 will only fit with some modifications (custom manifold/ducting) and will spool pretty late compared to the GT17s, but when they do spool will produce a lot more air mass at the same boost pressure and enable very high performance numbers. Anything larger will probably not spool on the 1.9l TDI engine in a usable window at all even with large injection systems.

More about Turbos

A very good source of information about turbos are the Garrett Turbo Tech guides. You should really study them, there are a lot of good hints and examples contained within that will help you in planning your own remap while showing you what not to do, as well.

Check them out at:

http://www.turbobygarrett.com/turbobygarrett/turbo_tech_basic

http://www.turbobygarrett.com/turbobygarrett/turbo_tech_advanced

http://www.turbobygarrett.com/turbobygarrett/turbo_tech_expert

This will give you all the necessary knowledge to choose the right turbo for your application and recognize common pitfalls that create problems when remapping (surge, overspeed, very low efficiency, …).

Cooling

More power generates more heat – in more than one place. For one, higher boost levels mean higher IAT (intake air temperature). This is due to the fact that air gets hotter as it gets compressed – it does get cooled by your intercooler, but hotter air in means hotter air out.

If you run longer periods of high load, your engine coolant and oil will also become hotter and hotter – with disastrous consequences. Same goes for your gearbox.

So take an uprated cooling system into account – a better intercooler never hurts, though it will not generate performance by itself, it will give better efficiency at higher boost levels and ambient temperature levels (i.e. summer). It will also make sure that you do not have thermal failure when you hit it during summer – mediocre intercoolers can let IAT rise to near 100°C at WOT…higher IAT means higher combustion temperature and EGT, which means your turbo is glowing red and thinking about ditching a wheel if you keep on abusing it, your pistons are about to melt, …

>150hp, you should really think about using an extra or larger single oil cooler/heat exchanger with a thermostat on an ALH if you plan to use the power for extended periods of time.

Engine internals

On VAG cars, you could also exchange the stock pistons with some PD ones (but you'll have to switch to trapezoid conrods – from a BLS or ATD, for example – to be able to fit the PD pistons) and if you get the right pistons (from an ARL, but just the pistons – ARL/ASZ conrods will not fit), you can also realize a compression reduction just via the pistons themselves while reinforcing your engine via better piston coating and cooling. You'll also have to use the new-style oil cooling jets to fit these pistons, though!

You can install uprated conrod bearing shells with better surface treatment – use sputter bearings if you can, just make sure they fit your crank shaft – the ASZ/ARL ones will not fit, just like the conrods.

You could also realize a compression reduction via a thicker cylinder head gasket, but this is not the best method. However, if you've already got it apart, you could exchange the head bolts for 12.9 quality ones (stock are 10.9) if you plan on high boost levels (about 1.8 bar over ambient and above).

Brakes

It is an often-overlooked fact that more power needs better brakes…do yourself a favor and think about a brake upgrade! More stopping power is a good thing.

The following upgrades are recommended –

FN-3 instead of FS-3 front brake system – this enables mounting 288 or 312mm discs with 25mm thickness vs. the 280/22mm ones that are mounted stock. There are even larger brake options that will fit with some adapters from larger Audis and Porsches.

Steel braided brake lines

Electronics/Sensors

To be able to use more than about 1.6 bar of boost above ambient, you will need a new boost sensor. Actually, you'll need it to run more than 1.2 bar safely, IMO – since otherwise there is no safety margin to engage limp mode anymore and it will not trigger even though it may overboost massively – so if that happens, without a boost gauge, the first warning you'll have of your turbo's impending doom will probably be when it's way too late to save it….I'm speaking from experience here.

This is obviously not that important for a stage 1 remap, as 1.2 bar of boost are quite enough for this purpose, but when you get to higher power levels, should be one of your first considerations. In order to use it, you will need to adjust sensor linearization and diagnostic limits/factors as well as your MAP- or MAF-based calibration maps. This will be described in the stage 2/3 chapters.

What nozzles and what plunger piston should I use?

In general – larger numbers mean more injection quantity, but more is not always better. An ALH (European) uses a 10mm pump plunger piston and 5-hole nozzles with .184 µm hole diameter to achieve a maximum of 51mg/stroke (albeit at very long injection times); even though the stock map never injects nearly that much, the pump voltage table goes up to 51mg/stroke.

The reason this combination is used by default and not larger .205, .216 or .232 nozzles along with the 10mm plunger piston is that small nozzles combined with high injection pressure make for very good atomization/evaporation of the injected fuel quantity, which leads to better combustion, emissions and less smoke – but they will also strain the pump and timing belt more, though this should be negligible if you adhere to belt change intervals and use quality parts.

Let's explain this by comparing two different nozzles on 10mm pump plunger, both injecting the same net amount of fuel (5 and 50 mg/stroke, the pump voltage map values are taken at high rpm).

1) .184 stock nozzles – due to the smaller openings at the nozzle tip, pressure builds up better/more quickly. The nozzle starts to inject earlier and needs later SOI (Start of Injection), but it takes longer to deliver high IQ
2) .216 upgrade nozzles – in contrast, the larger nozzles need earlier SOI (further BTDC – before top dead center) because they build up fuel pressure a little more slowly, but it takes a lot less time to deliver high IQ

Nozzle comparison - 5mg/stroke

.184 nozzles will need about 1.5V pump voltage to deliver 5mg/str
.216 nozzles will need about 1.7-1.8V

Nozzle comparison - 50mg/stroke

.184 nozzles will need about 4.7V
.216 nozzles will need about 4.2V

This should serve to demonstrate that just scaling the pump voltage map will NOT work! We're changing a hydraulic system here, it's a bit more complex and definitely not proportional.

Basically, a larger plunger piston and smaller nozzles are the way to go – within reason. I.e. you should not combine a 12mm plunger piston with .184 original nozzles and expect huge power...instead, you'll put huge strain on your timing belt and pump while still not being able to inject a lot of fuel in a short time due to the small nozzles.

Also, be aware that the plunger piston limits how much fuel you can inject – this is a hard limit and not changeable other than by switching to a larger one. Look at area for a comparison of what they can do – i.e. an 11mm plunger piston will not deliver 10% more fuel volume, but 21%.

Popular nozzle/plunger combinations

.205 or .216 nozzles, 10mm plunger – the largest you should go on a 10mm plunger IMO.

Though .232 and above do work, they get smokier and smokier due to bad atomization – however, this can be partially offset by adjusting the injectors to higher opening pressure. A larger plunger piston is still the better option IMO if available to keep injection times low.

.216 or .232, 11mm plunger

.232+ on a 12mm or larger plunger for extreme performance

Performance

It's tough to attach real world performance numbers to these combinations, because everyone is comfortable with a different level of smoke and hardware abuse and has performed a different amount of mods in a different level of quality.

I'm more comfortable attaching maximum performance or rather injection quantity limits to pump plunger pistons – since their displacement determines the maximum fuel flow that can happen in an absolute way. Google for VP37 functional descriptions and look at how they work, you'll see why.

The 10mm plunger can be used to inject about 57mg/stroke maximum (70 mm^3/str according to Bosch docs, converted to ambient temperature is about 57mg/str) with .216 oder .232 nozzles with very long injection times. The ALH stock map only goes up to 51mg/stroke – why? Simple answer: because of pumping losses and finite maximum flow of the nozzles.

The higher internal pressure with the stock nozzles (remember, smaller opening, higher pressure?) means that a small amount of fuel cannot be injected but is instead forced backwards into the diesel return line to be injected another stroke, about 6mg/stroke at ambient (fuel) temperature.

Also, smaller nozzles have a finite max flow, meaning that it will just take too long (in degrees of crankshaft rotation) to inject all the fuel even if you adjust SOI as far as you can, which increases EGT a lot because EOI (End of Injection) and the resulting pressure maximum happens way too late to be able to exert much force on the piston, which is already travelling downwards very quickly away from the expanding flame front – decreasing pressure and therefore temperature inside the combustion chamber and slowing combustion, which also serves to reduce effective power. Due to this, fuel combusts unevenly and is left unburned inside the cylinder and continues to combust while passing the turbo and exhaust, massively increasing EGT and decreasing efficiency.

So with the larger injectors, the pressure buildup is less and so are the pumping losses, nearing zero with .232s, and the whole IQ fits into a usable time window, albeit with worse atomization.

The VP37 can inject in a window of about 17-20° BTDC to about the same ATDC, however, if the resulting pressure maximum happens too late, efficiency will be much reduced. The main combustion event should have its maximal pressure about 5° ATDC (after top dead center) for best efficiency.

How does injection work?

This needs a short explanation – an injection cycle is made up of a few events. There is the SOI – start of injection – which is the moment when fuel starts being injected.

The first injection event is a pre-injection of a very small fuel quantity to prepare the combustion chamber, pre-heat it and reduce noise. Mechanically, this is realized by the first stage of the injector – it will open at 220 bar of pressure on an ALH or other VAG Euro3 VEP cars, 190 bar on Euro2 cars. You should increase the stage 1 opening pressure on Euro2 cars to close to 220 bar if you do nozzle upgrades to improve atomization.

The plunger piston keeps on compressing fuel as it rolls over the cam and when pressure reaches 300 bar, the second stage starts injecting – this is the main injection event.

Based on the pump voltage map, the quantity adjuster will release all remaining compressed fuel from the plunger into the return line at a specific point in time, stopping the injection as soon as the pressure falls below stage 2 (300 bar). This is important so the injectors do not “drip” – atomization is crucial, if injection pressure is too low it won’t work, so it needs to stop without any more flow. This is the EOI (end of injection).

This is all realized mechanically on the VP37 – the quantity adjuster’s mechanical position determines when the pressure is released from the pump plunger and therefore actual injection quantity. The injectors respond only to hydraulic pressure via spring systems and are not directly controlled in any way/passive.

Fuel delivery maxima

The 11mm plunger can be used to inject about 21% more fuel than the 10mm one - 21% more than 57mg/stroke is about 69mg/stroke. A 12mm plunger will be able to inject ~44% more than a 10mm one, or about 82mg/stroke.

All these are theoretical maximum numbers (at ambient fuel temperature, meaning around 25°C! fuel density changes with temperature, it gets less dense as it gets hot, you could use a fuel cooler) which will be limited/reduced by your nozzle choice and how high the resulting pressure levels and injection times are. It doesn’t help to be able to inject fuel that you can’t burn because it takes too long to inject it.

Inside those limits, you can use pretty much any nozzle/plunger combination and find your own compromise between power, smoke and EGT levels.

You can use some tricks to inject a little bit more with any plunger size by tweaking your pump voltage map and mechanically adjusting the quantity adjuster as far away / to the highest possible quantity as you can while still being able to inject little enough for idling or coasting in gear. Search the ecuconnections forums for more information on this topic.

Chapter 2 – a basic Stage 1 remap

Get a boost gauge, folks!

Do yourself a favor and install a quality boost gauge with warning function (best if it's a very loud buzzer so you'll notice it even with stereo blaring). It will save you a lot of trouble and money if things don't go as planned – again, I'm speaking from experience here…blowing your turbo isn't as much fun as it's made out to be.

Adjust smoke limiter, torque limiter, driver's wish

I won't go into the basics of identifying and working with maps here, there are various very good guides on ecuconnections to help you, no need to reinvent the wheel.

Basically, there are 3 main limiters to determine IQ (injection quantity):

1) Smoke limiter – axes are air mass in mg/stroke and rpm, values are IQ in mg/str.
2) Torque limiter – axes are rpm and ambient air pressure in mbar, values are IQ in mg/str.
3) Driver's wish – axes are pedal position in percent and rpm, values are IQ in mg/str.

The lowest of these values at any point is used.

You should shape your maps so that the driver's wish is the highest of the three – then the smoke limiter, and the torque limiter should fit inside the area enabled by the smoke limiter (be the smallest of the three limiter values).

In the map editor of your choice, identify and modify the smoke limiter, torque limiter and driver's wish map to increase your fuelling levels. You may have to modify the map axes slightly to be able to use full IQ for the smoke limiter.

Try and stay above 1:18 AFR – meaning, for every mg/str of fuel, the smoke limiter map should have 18 mg/str of air mass. So to inject and cleanly burn 50mg/str of fuel, 900mg/str of air mass should be sufficient. Actually, you can usually get away with 1:17 to 1:17.5 without visible smoke, but don't go below this.

Also be aware that without further modification, you're limited to 1000 mg/stroke air mass maximum in the smoke limiter map. We'll get to why and how to get around this in a later chapter – however, for a stage 1 remap, this is absolutely sufficient as explained.

Be careful with shaping your torque limiter – don't increase torque too much below 2000 rpm, better have your torque max at 2500/min to save your gearbox, DMF and clutch.

Calculate how much torque you will need for about 275Nm on an ALH or other 5-gear manual car with DMF/stock clutch and don't go above this value. The stock car has 210Nm@1900, so you should be able to figure out a number. Also, don't go much above 120hp (again, you can calculate from the 90hp@3750 the stock file has – horsepower is just a function of torque and rpm!) or your turbo will die due to high EGTs because your injection times will be too long.

Adjust requested boost and N75 map

Now, you'll need some more boost to be able to burn the increased fuel levels cleanly – or rather, you don't need more boost, you need more air mass – but that gets created by boost (and improved by cooling). The stock requested boost map goes up to 1950 mBar absolute pressure or 0.95 bar above ambient.

Why is cooling important for boost? Simple – cool air contains more oxygen, which is what we need to burn (oxidize) fuel. This means that just having lots of boost isn't very effective – you need good boost cooling to really take advantage of it, as well.

The stock turbo will not do much more than 1.2-1.25 bar for longer periods of time safely. However, this is enough for a stage 1 remap.

So where you increased fuelling, also increase your boost pressure – in a sensible way, meaning don't request way more than the turbo can create in your map, that will lead to spikes. Be especially careful low down (<2k rpm) to prevent surging (uncontrollable heavy overboost, the turbine wheel accelerates very hard in a very short amount of time, which puts massive mechanical strain on it and can cause it to break).

Analogous to this, take care to open the VNT vanes a bit more where you inject more fuel – and adjust the N75 map axis if you go above it, extrapolate.

You can also "cheat" and look at other cars with higher power output from the same range. The requested boost values and N75 map from the 110hp VEP and 115/130hp PD model might be a good start, for example.

Adjust further limiters (SVBL, boost limiter map)

Now, without adjusting some more limiters, we will not be able to use these boost values. Namely, there are two – the SVBL (single value boost limiter) and the boost limiter map.

The SVBL is – as the name suggests – a single value. On the ALH stock file, it has the value "1990" and stands for 0.99 bar above ambient. This is 40 mbar above the highest value in the requested boost map. The ECU uses this as a sort-of tuning protector – your requested boost values above the SVBL will not work.

The boost limiter map itself is used as a maximum value for requested boost after being adjusted for ambient pressure, temperature and fuel quantity. This adjusted value is then limited by this map based on ambient pressure and rpm. On the stock file, the map is flat at 1.15 bar (200 mbar above requested boost max) until 4500 rpm, then falls to 0.85 bar.

This information is available in Bosch EDC15VM+ documentation – a document you should find and read (it helps to know german…but Google Translate is your friend).

Turbo-induced limp mode

To explain how limp mode (for turbo pressure) works: there are two maps that determine the maximum positive (400 mBar default) and negative (300 mBar) allowed boost deviation – if boost levels are outside these for a few seconds, limp mode will be triggered and a diagnostic entry will be stored in the ECU about this event. These are calculated above/below requested boost!

These are called:

maximally permissible negative boost offset for fault control / ldwREGMXnR / 1x1

maximally permissible positive boost offset for fault control / ldwRMXpRKL / 10x1

The second map is a 10x1, but is flat at 400 mbar on the stock file.

Take care to adjust all these limiter maps sensibly, take into account what your turbo can do and don't overload it.

Also be aware that the stock boost sensor is maxed out at 1.6 bar above ambient, so above about 1.2 bar requested boost, limp mode will not trigger at all…unless you adjust the maximum positive deviation or install a MAP sensor that can measure higher pressure and the associated linearization and diagnostic values.

Chapter 3 - stage 2 remap

Again, as with a stage 1 remap – get a boost gauge, folks! I'm not kidding…

Necessary hardware modifications

So a stage 1 remap has become boring or you simply want more power – maybe a stage 2 remap is for you? While the power gains are a lot higher, you'll also need to change your car's hardware – quite a bit, if you want to use all that newly gained power more than for a few seconds…

You will need to increase your fuelling levels by mounting larger nozzles. As this allows you to inject more than the stock limit of 51mg/stroke, you will also need to remove/change a lot of limiters and their associated scaling factors - or you could do it the quick and dirty way by decalibrating your map like most "professional" tuners…but then, you wouldn't be reading this guide.

You will also need to create a custom pump voltage table for your plunger/nozzle setup – this is a time-consuming process, unless you're lucky and VAG has already used your combination somewhere…it pays to look around.

Basically, the stock clutch and dual mass flywheel will not take the load a stage 2 remap puts on them very well. The clutch will slip, the flywheel will go on block (the springs will not dampen anything) and will quickly be ruined – so you will need to upgrade them. A single mass flywheel and an uprated clutch should do the trick, a 6-speed conversion too.

Recommended hardware modifications

You should remove the EGR in software or block it mechanically – this will improve part-load response and spoolup.

The catalyzer also restricts your turbo and makes it work harder by increasing back pressure and EGTs – you will still pass emissions tests without it (at least where I live). Be aware that both these changes are probably not road-legal where you live, so use caution and common sense!

An unrestrictive exhaust system is helpful for turbo diesel engines, less back pressure means less turbine rpm for the same effective boost.

An uprated intercooler system would be a good idea – but not absolutely crucial yet.

An uprated turbo could be useful – but it's not required at this stage. Also, don't fit a 2xxx turbo at this stage – you won't be able to make it spool.

A 3 bar MAP sensor would be a good idea – not required, but you won't have limp mode if you don't mount one and modify your ECU to be able to use the higher values.

Creating a custom pump voltage table

After installing larger nozzles, it's time to let the ECU know about this change so it can properly regulate smoke levels, consumption, torque and so on.

The ECU uses the pump voltage table to determine how much voltage to feed to the quantity adjuster for a specific injection quantity at specific rpm. By default, it has columns up to 51mg/stroke for the stock injectors.

Let's assume for this guide that you will use a 10mm pump plunger and .216 injectors for a maximum IQ of about 57mg/str. In previous chapters, we've learned that changing injector size alters how they behave, so let's take that into account. Larger injectors with the same size pump plunger means pressure buildup until fuel is injected at 300 bar opening pressure takes longer. This in turn means you have to adjust your pump's static timing mechanically – it needs to start a bit earlier than with the stock nozzles to have main injection start at the same time as before.

It also means that for small quantities, more voltage is needed than with the stock nozzles – but, conversely, that less voltage is needed for higher quantities.

So let's start out by recalculating our IQ axis in the pump voltage table – figure out a factor to convert from 51 to 57mg/str and apply it. Now, start by – slightly! – adjusting voltages at low IQ (up to 5-8mg/str) upwards and scaling voltages down slightly at high IQ (>30mg/str).

Now, all of this is just a starting-off point. You'll need to do log runs while watching smoke levels (cheap version, not so accurate) or, ideally, with a wideband AFR and high-resolution logger to verify what you have set up has any real-world relevance. You can also try and find pump voltage tables from cars using your plunger/nozzle setup – however, be aware that the pump roller cams influence this table, as well, so unless your pump has the same one as that car – it won't be accurate anyway, so some work will probably still be required.

However, if you try and see whether you can actually inject that much now, you'll notice it won't work yet. VCDS will at this point not show above 51mg/str, neither will pump voltage go above the values specified in the 51mg/str column if it exists or where it would be, interpolated between existing columns. For this, you'll need to extend diagnostics and limiters.

Extending diagnostics

By default, IQ, air mass and boost have maximum values that can be displayed via diagnostics. To be able to display more, you will have to change message numbers (for boost) and diagnostic factors (for all).

All diagnostics work according to the same scheme on EDC15VM+ cars (and probably similar on other EDC15 versions) – there is a table detailing all existing KWP1281 message numbers, their associated formulas and whether they have a specific unit or are general purpose. Search the ecuconnections forums for it, thanks dieseljohnny. There are usually 8-bit factors determining message numbers and 16-bit factors to convert these values for internal ECU use.

Boost

Let's have an example. Boost on my ALH stock file has message number 18, the associated formula is:

0.04 * A * B, unit is mbar

Before we continue, a hint – get used to switching your map editor view between 8 and 16 bits. The message numbers are 8-bit; on the stock file, we can find the following pattern in various places:

18 255

Now, if we combine the formula for message number 18 and the following value and take 255 as the third (the maximum for an 8-bit value – a byte), we arrive at the following values:

0.04 * 255 * 255 = 2601

2601 mbar is indeed the maximum boost value that is actually displayable via diagnostics – do you see a pattern here? Now, why are we using 255 as the third value? Diagnostics send the actual values as a byte, and these can range from 0-255 - since we're calculating maxima, 255 it is.

To be able to use more than 2601 mbar of boost, we will need to change this. A common choice is to upgrade to a 3 bar MAP sensor – to be able to actually display any higher boost values via diagnostics, you will need to change the message number and associated factors.

For boost, another message number is available, which is also used on the models with more stock power. We will use message number 8, associated formula is:

0.1 * A * B (without a specific unit)

So we need to change these 18 255 occurrences to 08 xxx – for example, 3060 as a maximal value would need 3060 * 10 / 255 = 120 as the value for xxx. However, without a 3 bar MAP sensor and the correct linearization, we will still only be able to display this boost – but never actually see it…

Now, for the ECU to be able to recognize these values correctly internally, you will also have to adjust a 16-bit factor associated with these messages. Look for this single decimal value on the stock ALH file – it will be a bit after the 18 255 occurrences that we just changed and outside any other maps:

980

We increased the total amount to be displayed, so we have to decrease the 16-bit factor that converts it for the ECU's internal use to scale it correctly. So since we scaled from 2601 to 3060, we need to decrease this value by the same proportion.

3060 / 2601 ~ 1.1765

980 / 1.1765 = 833

IQ
Since 51 mg/str is our default IQ maximum, all diagnostics are set up to accommodate this. For IQ, we will not need to change formulas, but we will have to change some diagnostic factors.

Look for these single values inside the Audi A3 VP37 damos file/WinOLS and then locate them in your file and increase/decrease them proportionally to your maximum IQ change.

SIG-A obere M_E-Grenze zur Ausgabe TQS-/VBS - increase

max. Verbrauch/Anzeige - decrease

Steigung fuer Diagnose Umrechnung Mengen - decrease

This is still not enough to be able to use more than 51mg/str – for that, we will need to change some limiters – in the next section.

Air mass
Air mass is limited by default to 1250 or 1275mg/str, usable air mass (in the smoke limiter map) is further limited by another map we will get to later to 1000mg/str. However, we can use our MAF to display values above this and run a working MAF-based smoke limiter for high-powered setups if we adjust diagnostics.

Reason being, the MAF linearization goes up to about 2920 mg/str @2k RPM or about 1460mg/str @ 4k if you convert it – the linearization map is in kg/hour, not mg/str, so don't be fooled by it only going up to 796 in absolute values. You do not need to change MAF linearization unless you use a different MAF housing! Be careful: the 13x1 map the EDC15P+ Suite calls MAF linearization is not the correct map. It's actually a 32x1 map that does not get autodetected by WinOLS. Hint: search for 32 decimal in 16-bit mode.

Be aware that there is a further limiter for air mass; on the VP37 damos, it's set to 700 kg/h (anwLMM_MAX). Any values above this will be ignored and the readout will stay at 700kg/h (should be enough though…).

You can calculate mg/stroke from kg/hour as follows:

Air mass (kg/h) * 1000 / 3600 = Air mass (g/s) * 1000 / 3600

700 kg/h / 3.6 = 194,44 g/s = 194400 mg/s

Air mass (mg/stroke) = Air mass (mg/s) / rpm/s / 2

1461,65 mg/stroke = 194440 / 66,666667 / 2

I've set mine up for a maximum of 1500mg/str. This is enough to burn 83,33 mg/str of fuel at 18:1 AFR (clean).

Look for the following singles (proportionally increase *Normierwert*, decrease *Steigung*):

Normierwert Luftmenge

Normierwert ARF_Soll

Normierwert ARF_Ist

Steigung fuer Diagnose Luftmasse unnorm.

Steigung fuer Fehlerspeicherung Luftmasse unnorm.

Steigung fuer Diagnose Umrechnung Luftmasse

Extending boost/IQ/air mass limiters

Now that we have set up our diagnostics to be able to display our targeted maximum values, it's time to let the ECU know we want to use them, as well!

Boost

There are no further special limiters above what was discussed before (SVBL, boost limit map) – set up your requested boost/N75/boost limit map/SVBL to take advantage of higher boost levels.

IQ

The story is very different for IQ – there are various places in the binary that need adjustment. All of these will have the 8-bit decimal value 51 (for 51 mg/str) on an ALH original file and be outside any map.

All of the following singles are pretty close to each other and in sequence. On the stock file, look for this 8-bit pattern:

39 51

In general, no matter what mg/str your IQ is limited at, you'll always find the pattern 39 xx where xx stands for the IQ limit.

Pump voltage IQ limiter

Driver's wish IQ limiter

Start IQ limiter

Smoke limiter IQ limiter

Cruise control IQ limiter

Automatic gearbox IQ limiter

Torque limiter IQ limiter

After you've successfully changed all these limiters, you can now use your new IQ limit everywhere, have it displayed correctly via VCDS and via your consumption meter in the dashboard – FINALLY!

Air mass

To be able to have a working MAF-based smoke limiter at high IQ, you'll need to extend a calibration map for air mass. Look for a 10x16 map with temperature as one axis and values up to 10000 on the other where all map values are flat across the board. It's called

BEG Rauchbegrenzung korr. Luftmasse

in the VP37 damos.

There will be several maps like this, one that goes up to 2500, this is for boost, one that goes up to 10000, this is for air mass. Remember the boost one, we will need it later on.

Now, change the last column of the air mass related map to read 15000 instead of 10000. Change the axis value as well as all map values. This will enable you to use an air mass of up to 1500mg/str in your smoke limiter!

Calculating and adjusting SOI

What is SOI?

SOI (start of injection) together with pump voltage is what controls diesel injection on VP37 cars.

It is an important parameter when remapping your ECU – as discussed before, ideally the combustion pressure maximum (close to EOI, end of injection) should happen somewhere around 5° ATDC. For this to work, you will need to adjust the SOI and limiter maps.

There are quite a few SOI maps, WinOLS will not recognize them (only the first), you will need to do that yourself – this is because they share the same map axis! Define these maps manually and add the shared axes from the first map (-20°C on the ALH stock file, according to the selector map, 10x1 right after the last SOI map). They are adjacent to each other without any spaces – you'll figure it out.

It's all absolutely relative…

Now, since the VP37 pump is controlled by hydraulics/mechanics and not electronically like the PD and CR diesels, there is no absolute way to control SOI or duration in terms of crankshaft rotation degrees like on PD/CR cars, only indirect control is possible. Also, due to mechanical limits, you cannot use much more than 20-22° BTDC as SOI on these pumps, which complicates things further.

What you can do is control the duty cycle of the valve that regulates pressure and controls SOI indirectly by this, and assign a value in degrees crankshaft for a specific voltage/duty cycle, sort of a calibration map, like the pump voltage map.

For this, log rpm, actual SOI and SOI valve duty cycle/voltage. You will be able to adjust your map to sensible limits.

Be careful with increasing SOI – if injection starts too early, you will exert a high amount of negative torque on your engine's internals – your conrods will not like this and may bend/break…also, by starting injection way too early, diesel can "wash" the oil film off the cylinder's surface and combust anywhere instead of inside the omega-shaped hollow inside the piston, where it's supposed to. This will lead to high temperatures inside your cylinder, high EGT and may melt your piston or kill your turbo.

At high IQ values (with larger plunger pistons, especially), you should think about mounting a secondary fuel pump to make work easier for your VP37 – otherwise it may be tough to hit high SOI values and inject all you want to.

Calculate SOI

So how do we figure out a sensible SOI? This is a matter of debate, but what has worked for me is to compare SOI on the stock file to the pump voltage map. Knowing that ideally, the pressure maximum happens 5° BTDC and the OEM will have optimized for this, we can now look up SOI for a specific quantity at a specific rpm, compare this with pump voltage at this specific rpm and calculate a conversion factor for pump voltage to degrees crankshaft.

Using this factor, we can now calculate our own custom SOI table – conservatively, start on the low side…

An example (values are fictional):

At 30mg/str and 3000 rpm, the preset SOI is 9° BTDC. The pump voltage for this setpoint is 3411 mV. Since injection should end at 5° ATDC, we have 14° of crankshaft rotation for these 3411mV at 3000 rpm. So for every degree of crankshaft rotation, we have 243 mV of pump voltage in this example.

Calculating SOI for 50mg/str@3000 for the same nozzles would mean an addition of 66% SOI, or 14 * 1,66 = 23,24 – meaning we can inject 50mg/str @ 3000 rpm and have ideal combustion, since we can go to about 20° BTDC and have 5° ATDC, so we have about 25° crankshaft of total duration to work with.

Now, when we change nozzles, of course we change static timing, as well. This should be taken into consideration for SOI conversions. Still, a specific pump voltage will lead to very similar injection duration/EOI, no matter what nozzles are used – only the moment when the second injector stage opens changes. This means that we can use our factors from the stock file to pre-calculate our SOI maps, then once the pump voltage map is close to reality, start logging and adjusting SOI along with pump voltage to get things in perfect shape.

This is a lengthy process, though – be prepared for lots of work and log runs!

Changing sensor linearization

To be able to use a 3 bar MAP sensor, you will need to first install one – VAG part number is 038906051C if you have a small sensor – 038906051A for the larger one, depending on your mounting option. My car needed the larger one (A). Installation is straightforward, but be wary of old mounting bolts – one of mine snapped because it was just ancient and had never been loosened. It was so rusty not much remained. I replaced both bolts, of course – **take care not to get any shavings into your intercooler**!

Now, after installing the sensor, you need the associated linearization – depending on your map sensor choice, it will either be the 3 or 4 bar map sensor. We will use the 3 bar sensor for our example.

There are stock cars using this larger sensor – the 130hp and 150hp PD TDIs. You can compare those files – on the stock file, look for this pattern:

82 989 200 2600

989 is the sensor voltage, it has 4.878049 as factor. So for the stock car, this gives:

400 4824 200 2600 – meaning, at 400mV it will read 200 mbar, at 4824mV it will read 2600 mbar.

The ARL/150hp stock file has these values:

400 4639 200 3000

Convert these and change them in your file.

N75 upper and lower limit

For a stage 2 or 3 remap, an adjustment of these maps may be necessary depending on fuelling and turbo geometry.

Reason being, the OEM did not set them up for increased fuelling levels, but for stock ones – so they may not give enough space to work with on a remap (though this is less of a problem on the file this guide is based on).

These maps set the upper and lower bounds for the boost PID controller to use at any rpm.

On the ALH stock file, both are 16x1 maps ranging from 0 to 5000 rpm.

MAP- and MAF-based smoke limiting

There are two bytes that determine which type of smoke limiter you'd like to use – 00 00 = MAF, 01 01 = MAP. 01 01 in 16-bit is 257; 101h -> 257 decimal.

Should your MAF not be able to measure enough air flow, be aging, not working or simply not be installed anymore, you'll need to switch to MAP-based smoke limiting. In comparison, MAF-based smoke limiting is already temperature-compensated because the MAF has a correction built in for this. When we switch to MAP-based smoke limiting, we need to take care of this ourselves!

Remember the boost-related MAP I wrote about before? We need it now – open it in your favorite map editor. On an ALH stock file, all values will be flat across the board, have temperature as one axis and go up to 2000 on the other and inside the map – however, this will not do. Remember, air gets hotter as it gets compressed, and the hotter it is, the less oxygen it contains per volume. The ECU needs to know how to correct for this, and that is what this map is for.

It also limits the maximum amount of boost you can use in your MAP-based smoke limiter – this is determined by the maximum axis value, pretty logically.

Now, ideally we need to calculate exact values here – but again, we can take a shortcut: there are cars using a MAP-based smoke limiter like the Fabia RS. Search the ecuconnections forums, you will find the way, also the formulas for calculating it yourself.

Limiting IQ based on temperature

First: why would we want to limit power? Simple: to save our engine and components in case things get out of hand for whatever reason. The EDC15 has lots of features to achieve this – there are two main groups:

1) OTF/ADF/TTF/KTF/LTF-based IQ limiting – this reduces IQ based on oil temp, atmospheric pressure, fuel tank temperature, pump fuel temperature, air temperature
2) Coolant temperature-based smoke limiting (only available via MAF AFAIK)

For the first group, these are 5 10x10 maps that you can find in the DAMOS – they are called:

BEG Begrenzungsmengenfaktor f=(xyz,N)

Use the 3-letter codes from the description above for xyz. Their axes are temperature and rpm, the values are percent with factor 0.01. So 10000/100% means full IQ as directed by the normal fuelling maps, 7500/75% means 75% of that and so on.

Obviously, you can only make use of the maps that you have sensors for – if your car does not have an oil temperature sensor, you won't be able to limit based on oil temp either.

For the second set, you should take a close look in front and behind the main MAF-based smoke limiter map – you will find two empty maps behind it that are identically sized as well as a small 3x1 selector map in front of it.

These maps allow for coolant temperature-based smoke limiting – meaning you can limit power if the coolant isn't warm enough yet, which isn't a bad idea. You could also use it to reduce power if it gets too hot, but that's really what the previous 5 maps are for.

To enable these maps, enter 0 256 512 (16 bit decimal) or 00 00 00 01 00 02 (8 bit Hex) in the selector map and adjust the axis according to your wishes.

Changing idle speed

There are several maps 2x1 and single value maps related to idle speed – one of them is used right after starting, the other for a set amount of time after engine start, another to preselect idle when both have timed out, and some more still. You can change the upper as well as lower values – usually, a slightly increased cold idle works nicely to warm up your engine that little bit more quickly – it also runs better when it's cold IMO. I've set mine up to idle at 1210 rpm max, decreasing to 900. Depending on your setup, you may want to run a lower or higher idle on your car due to other modifications or taste.

To fully change idle speed (not just after starting and during engine warmup), there are quite a few more maps (most of them singles) to change, along with a 4x5 map.

The way it works is this – the highest value of three maps (the 4x5 and the two 2x1 maps) is used to preselect the idle value. Then, during engine start, for a set amount of time (regulated by a single), the 4x5 map is used for temperature-based idle.

After engine start, another timer runs and regulates idle based on one of the 2x1 maps (mrwLTW_KL) until it too runs out or motor temperature goes above a certain setpoint, after which the two singles for idle when standing still or moving take over.

There are a few conditions when idle speed is regulated by some other factors, but these aren't vital. If you need them, you will find them.

Fitting it all together

Again, as with a stage 1 remap – adjust your fuelling and main limiters (DW/TL/SL), adjust SVBL and boost limiters, requested boost, N75, inverse driver's wish if you're using cruise control, …

Take care to stay within your hardware's limits – don't run very long injection times without at least investing in an EGT probe to not kill your turbo or pistons with thermal overload to be able to react, at least. Also, a restrictive exhaust system will make things more difficult and raise EGT and back pressure, so consider upgrading yours, start with the down pipe. The stock down pipe is very restrictive and narrow; it has a sharp 90° bend right after the exhaust manifold outlet, which is not ideal.

Chapter 4 - stage 3 remap

Armed with the knowledge from previous chapters, what else remains to do? Oh yeah, get a boost gauge! ….but you already have one, don't you? Better if you did…

Considerations and hardware requirements

For even higher power outputs, you'll finally need to upgrade your pump's plunger piston and cam, maybe even install still larger nozzles than for a stage 2 remap alongside everything else. This will require another IQ limit and pump voltage edit (among other things) – so it'll be a bit of work, but by this stage, you'll know what to edit and why, because you'll already have done it.

You'll definitely need an uprated turbo now – no way to hit these power levels with your stock unit. Read the planning section for some easily sourced choices that will fit with no or minor modifications.

An uprated intercooler to go along with the new turbo is a must at this stage.

You'll also have to reinforce various parts in your engine to make them be able to withstand the further added load – a thermostat-controlled oil cooler could help, same as a non-restrictive exhaust system.

An uprated clutch/flywheel is pretty obvious and covered in stage 2.

A 6-gear conversion would be a great idea at this stage – coupled with a single mass flywheel or conservative on torque below 2.5k rpm and a DMF, or it won't hold up for long at high power levels.

You can still get away with using a 5-speed gearbox with single mass flywheel, the same applies – don't go too high on torque below 2.5k rpm, and especially not in 4th/5th gear, without reinforcing your gearbox. This is not recommended and will not hold up forever unless reinforced, either…and reinforcement is more expensive than a 6-speed conversion.

At this power level, you may want to install a longer 5th gear if you want to go faster than your stock gearing allows – my ALH received a 0.7 instead of a 0.756 stock final gear and now shows 3200 rpm at 160 kph on the speedo, where it showed 3750 rpm before. That's good for a redline (4600 rpm, about) speed of 231 kph on my GPS.

This is useful for higher top speeds or lower average consumption at lower speeds due to lower rpm, but makes 5th gear unusable inside town.

With extreme components, quite a bit over 200hp is feasible with a 1.9l VEP engine – but it won't be cheap! Look around on the forums for some more extreme examples.

Be conservative with your low rpm torque limiter – I can't stress this enough! Your gearbox will thank you for it. This isn't where you create power – though lots of torque low down feels nice, your drivetrain (and turbo, if you request boost left of the surge line) is strained the most by this.

Try and leave room for limp mode – it's never a bad idea to have a safeguard for your components!

Always double-check your map edits, always do log runs to confirm what you changed. Compare to previous versions and the original for reference – often it helps to look at patterns from the original to determine the strategy to use.

Be conservative and work your way up instead of down – start low and increase if things work out.

Where to go from here

The world is your oyster if you successfully created a working, WOT-proof VEP TDI monster with all the bells and whistles – so many of these cars are still around, lots of them with owners waiting to unleash the beast within…get to work!

At this stage, figuring out how PD cars work shouldn’t take you too long – almost all of the concepts you used here are applicable there.

Common rail cars will be more of a challenge – but you grow with your challenges.

……to be continued……