Up to Speed

MANY PEOPLE IN THE FRENCH CAR COMMUNITY ENTRUST ESSEX BASED TUNING SPECIALISTS, ATSPEED RACING, FOR MAPPING OF THEIR ENGINE MANAGEMENT SYSTEMS. BUT WHAT REALLY GOES ON BEHIND THOSE BIG WHITE SOUND PROOF DYNO DOORS? ATSPEED RACING'S COLIN THORNDYKE EXPLAINS.

WORDS & PICS: COLIN THORNDYKE

The programmable engine management system is not just an expensive small electrical box, it's the key to unlocking the full potential from your engine and any of the crazy ideas you may throw at it - from wild camshafts and throttle bodies, to turbochargers and superchargers. There are many systems out there, all with their own advantages and disadvantages, however the best piece of advice I can give to anyone is use the engine management system your tuner is happiest using – it will save you money in the long run. Personally our ECU of choice is Omex. We find it is fast and simple to tune, full of features, and customer back up is outstanding. It's a professional level system with a clubman grade price tag - in fact a lot of it comes straight out of WRC. In this two part guide I will cover initial set up and basic checks, through to the tuning and mapping itself in part two.

INITIAL SET UP

The first things we check with the ECU is correct and stable communication with the laptop. The Omex system has had many versions throughout its life, but the software automatically changes itself to the correct version for your ECU, making connection very easy - something many systems are unable to do.

STEP1: ENGINE USE AND LOAD AXIS

Once connected we are able to access the Omex settings, and firstly we must establish what the engine is, and its intended RPM. Naturally aspirated engines use throttle position for main load, while forced induction engines use manifold pressure, or a combination of both by using background MAP (manifold absolute pressure) based boost pressure corrections. The engine we are tuning in this article is based around my own turbocharged 16V Peugeot TU engine. The ECU is set to use MAP as main load, and the MAP sensor is checked for correct scaling and calibration. Our load (y) axis can then be calibrated - 0kpa is 1bar vacuum, 100kpa is atmospheric pressure, 200kpa is 1bar boost and 300kpa is 2bar boost. Generally we select around a 40% of the load axis for vacuum, 60% for boost, however this particular engine has very wild camshafts, and big valves, so obtains very little vacuum under normal driving conditions. This car must also be driven on the road, so its important to allow for fine control at these points by smaller jumps between cells, the ECU automatically interpolates between cells, but on an engine like this, its common to find one cell is not enough, especially when large injectors are used. Similarly with TPS (throttle position sensor) based maps we often have ▸▸

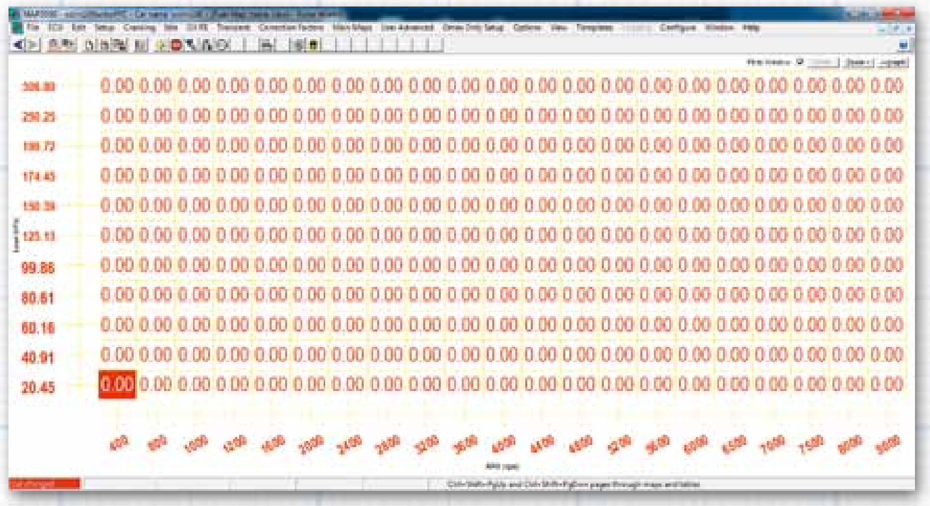
very fine steps for the first 50% of throttle opening, for more accurate fuel control at light loads and normal driving.

Once our load column has been set, we now move onto our RPM (x) axis. We set our first cells with emphasis for fine idle control, 400-800-1000-1200 rpm, if we say 1000rpm is our target, we have fine control of fuel and ignition changes either side of the target idle site which will aid us later on with idle fueling and idle controls. Based on the intended rev limit of the engine, the rest of the RPM axis is the scaled accordingly, usually in 400rpm steps. We need to allocate for the high revving of this engine, so after 6000rpm the RPM steps increase, as we require less fine ignition and fuel control here. On some very highly tuned NA race engines, its common to find a point in the engines RPM range, due to a combination of camshaft and engine design, the engine suddenly demands more or less fuel at a particular RPM, in the days of carburettor tuning this had to be ignored causing a temporary dip in power and torque, but now we are able to correct for this by giving the ECU finer control at that exact point in the RPM range where this occurs sudden fuel desire occurs. Carburettors are reactive, fuel injection is active.

Once our load and rpm axis has been set, we can now program a base fuel and ignition map, we are now ready to check and calibrate correct function and parameters of the other engine sensors.

STEP 2: THROTTLE POSITION SENSOR (TPS)

Although this car is being mapped fully with its main load as MAP, the TPS sensor is still required, and is still important to be set correctly. The sensors RAW value has a sweep from 0 to 255, firstly we like to check the sensors operation by making sure the throttle has full operation without reaching the sensors limits, and also to check its operation is smooth, and also operating in the correct direction, e.g. higher value for more throttle. Faulty sensors can often appear fine at light throttle but can give false readings once more throttle is applied. The TPS minimum RAW value ideally needs to be set around 20-30 as 0% throttle, and 100% wide open throttle (WOT) around 200 raw value, this gives the sensor a good sweep to work in, they work better if kept away from their extreme min/max range. To set this the throttle is fully applied, (and physically checked for WOT, the raw value recorded, and its value entered into the Omex software, and obviously the same procedure reversed for minimum value, in this case the TPS min and max are 26 and 216 respectedly.

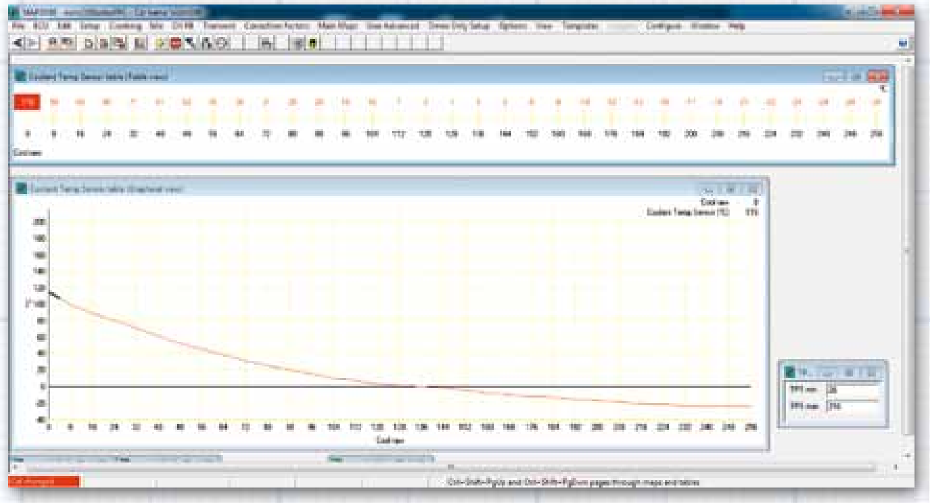


	400	800	1000	1200	1600	2000	2400	2800	3200	3600	4000	4400	4800	5200	5600	6000	6500	7000	7500	8000	8500
306.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
250.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
199.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
174.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
150.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
125.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
99.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

So why is the sensor required if this car is being mapped with MAP as main load? The TPS sensor is responsible for many things occuring in the background of the ECU, it has an effect on crank/start fueling, idle conditions, rev limits, anti-lag, and transient/acceleration fueling, all of which are based on where the TPS sensor is set, and or how fast its value changes during throttle operation. More on this later.

STEP 3: COOLANT & AIR TEMPERATURE SENSOR

Possibly one of the most relied on sensors as far as background controls go is the coolant temperature sensor. Its job, as its title may suggest, is sensing the coolant temperature. Engines work very differently at different temperatures, so we need a means of controlling this by altering fuel and ignition based on temperature. It is also used for cold start fueling and enrichments. To calibrate this sensor we have a coolant temp sensor table with RAW value 0 to 255 VS temperature. the raw value is basically the voltage (usually 0-5v) but expressed as a range of 0 to 255. Omex sell sensors, and can supply values for correct set up. If you are using your own, you can calibrate this by placing the sensor in cold water and heating it up, and with a thermometer, recording the temperature when the sensor reaches the centre of its RAW site. This way you end up with 90% of the sensors scale filled in, the far extremes (e.g. -30 or 120 degrees, which you will struggle to set at home) can be calculated by viewing the table as a graph view and manually entering in the values following the curve formed by the coolant temp sensor table.



The Air temperature sensor has a similar job, although its corrections are much smaller. But it is calibrated and set up in a very similar way. An infa red thermometer can be a useful aid in sensor calibration, but only if it is accurate.

STEP 4: CRANKSHAFT POSITION SENSOR & TIMING ALIGNMENT

Most modern cars have a magnetic inductive pulse pick up/trigger wheel on the flywheel, with a missing tooth. The crankshaft position sensor is responsible for reading this pattern and telling the ECU where the engine is in relation to TDC (top dead centre) this is critical for ignition timing set up, and injector timing. Its important to make sure the ECU is set up for your particular trigger pattern, its easy to make an engine run, but not correctly unless this is set up, there is a dedicated tooth control table section in the Omex User Manual.

Correct and accurate timing alignment is CRITICAL. I have seen many engines wrecked simply because the tuner did not synchronise the engine and ECU timing correctly, this can cause the engine to be run at an excessively high ignition value, and possible severe damage or destruction of the engine, despite the ECU displaying a "normal" value. To avoid this, ECU and engine have to be synchronised. For correct synchronisation, firstly an accurate TDC mark must be obtained. usually for this a spark plug is removed (a good time to check for correct spark plug grade), and the engine turned by hand until the piston reaches TDC on number 1 cylinder. an accurate line is then painted on the bottom pulley. Its important to remember a lot of modern cars have harmonic dampers on bottom pulleys, which can sometimes move if worn, so ALWAYS check any existing TDC marks are accurate.With an acurate TDC mark obtained, a timing light is used to check the timing. Wasted spark systems may double the value shown on the timing light, so readings must be halved. To make this easier we temporarily set a large portion of the map to 10 degrees (so our target is 20 on the timing light) the engine is then revved to 2-3000rpm, so as not to be under any idle controls where ignition changes may take place, and the ECUs live ignition timing data is viewed to make sure no other changes are taking place. Timing alignment is the adjusted until the TDC marks line up, and the value entered into the ECU. A change of "1" equals 3 crankshaft degrees, so fine changes must be used for accuracy, once done, engine and ECU are now synch'd, now i know that when the ECU shows for example 30 degrees ignition, my engine is getting 30 degrees ignition.

OTHER SETTINGS BEFORE MAPPING

Generally before mapping we like to set a safe rev limit, just in case any problems occur, on more than once occasion we have seen cars with fresh installations suffer from throttles sticking open. Just dont forget to reset the rev limit to the desired value, i have had customers who have chased misfire problems only for me to find they have left a low rev limit, or boost cut in place. If the Omex is controlling cooling fans we set these to sensible values, e.g. on at 90degrees, off at 85 degrees. We also like to run through the other settings to make sure there is nothing in place that may effect our work later, or waste time, particularly coolant temperature factors, its important the engine is mapped in a state where it is not being altered due to temperature, otherwise you find that during correct operating temperature the main map is not correct and you have to redo it again. Most engines finish coolant temp corrections at around 60-70 degrees, so the engines main maps should always be mapped above this temperature, this way 0 corrections are in place whilst the main maps are being set, that way its the true readings you are altering. ■

NEXT ISSUE

Colin delves into the murky world of mapping!