

Engine Management

Engine management is a key component of any modern vehicle built today. The computers in many cases, totally controls the engine settings and functions (injectors and fuel system, ignition system, tacho, speedo etc). The ability to tune a modern car has been taken away from automotive mechanics and now sits with embedded engineers, electronic software engineers and specialised vehicle tuners.

Car manufactures spend millions of dollars on the research and development of these engine management systems. The factory computers are extensively tested and dyno tuned before the car is released on to the domestic market.

Once car enthusiasts start to modify the vehicles from factory specifications the whole tune of the car is off set. Intake and exhaust systems change the air flow parameters through the motor. Factory ECU's in most cases will detect this and compensate for the changes. The tune however will not be accurate and will require the program of the vehicle to be reconfigured to suit the modifications.

Many factory ECU's can be re-configured to suit the changes made or reprogrammed to produce more power by altering fuel and ignition maps from factory settings. This is done using a chip, or a board upgrade depending on the vehicle type. Subaru WRX's and Nissan Pulsar GTI-R require Board upgrades, where as Mitsubishi EVO 1-3, VR4's Hondas, Nissan Skylines, 300 ZX's, are all chip upgrades.

Not all factory ECU's can be reprogrammed, or re-tuned to suit the modifications to the vehicle. Many vehicles such as Toyotas, late model Skylines, and EVO's require a processor upgrade which are very costly and not commonly carried out. At present this upgrade currently can only be carried out properly in Japan, in which case an aftermarket computer or piggyback may be a cheaper and more practical alternative.

What sort of ECU should you use; this can get tricky, as quite often a factory computer can be modified to suit engine modifications. The only time this is not possible is when the modifications are very extreme or when the ECU is not re-programmable. An ECU is often put into the 'I don't want to spent too much' section of a rebuild. As we see it, an ECU should be worth 15 - 20 percent of what you have spent on you engine in total, as most often it is this that is insuring the other 80% of your budget stays in one piece.

So what are the advantages and disadvantages of factory ECU's

Advantages

- All ECU parameters set for engine type e.g. air & water temp compensation.
- Cost effective option (using plug in off the shelf chip, or even custom chip.)
- No modification of factory wiring required, easy to put back to standard.
- Chip or board upgrade is a quick drive in; drive out modification.

Disadvantages

- Not all ECU's can be reprogrammed
- Factory ECU generally does not have boost control, launch and shift control, anti-lag.
- No data logging ability
- Slow processor speed (in some cases)

- Only small number companies have ability to reprogram factory ECU's

So what are the advantages and disadvantages of aftermarket ECU's

Advantages

- Potential for boost control, launch and shift control, anti-lag, and NOS functions
- Can sometimes data log engine information.
- Easy to alter engine settings. e.g. hand controller, laptop
- Removes factory restrictions (boost/speed cuts, air flow meter.)
- May offer quicker processing speed. Fully tunable, so more power possible than factory item.

Disadvantages

- Costly to fit and tune correctly.
- Quality ECU's are much more expensive when compared to factory option.
- Performance of the vehicle heavily relies on the correct installation and tuning of computer

What systems are available and how do they compare,

Factory Engine Management (Re-programmable)

These are expensive and involved to tune, as they are not tuner friendly. Not many workshops have the ability to re-tune factory computers, but many may be able to supply and fit an upgrade chip or board. Processor speed of a factory system is usually around 16bit and 16mhz, so as fast and in some cases faster than many aftermarket systems. The technology in factory computers is often top of the line.

Factory systems can not offer such features as shift control, launch control, aux outputs, NOS control, etc, however these can often be externally added. The installation and system cost however is low, as the computer is already available and no wiring is required. Performance on the road is near perfect as the computer is designed for the vehicle and all correction factors are present and correct e.g. Air temp offsets, and cold start enrichment.

Overall it is very good value for money, and a great option for those with re-programmable computers. Often systems are over-engineered from factory with regards to processor speed, compensations and flowmeter size (Evo flowmeters can flow more than 430hp and enough for 11.3sec 1/4's). It suits cars, which are not too radically modified from standard.

Haltech E6K

Tuning of a Haltech is done using a laptop and the Haltech software. There is no hand controller available. Expect the Haltech to be very time consuming in the tuning process, as the software is very involved and is best done by someone experienced in using the Haltech. Processor speed is good being 16bit and 16mhz. The Haltech comes filled with features such as launch control, shift control, boost control, NOS control. The system does need to be wired into the vehicle and a Haltech air temperature and water

temperature sensor needs to be installed. The software setup can prove troublesome and in some cases additional modules may be necessary. The Haltech uses the additional sensors for its correction factors changing air fuel ratios, timing etc. The technology incorporated in the Haltech is very good, and up to date. On road performance, as with any after market engine management system, depends greatly on the tune it receives. The Haltech, combined with a good tune will yield good results. The system is good value for money if you wish to utilise the additional features provided.

MicroTech LTX8

MicroTech tuning can be performed either through the laptop software or the hand controller. The hand controller comes in the 2-line and 4-line variety. MicroTech also offer a plug in digital dash. The laptop software is very user friendly making tuning straight forward and consequently not as expensive to tune as many other systems. The processor is 8 bit and 16 MHz, which is sufficient for the functions the system performs. (fuel and ignition). The MicroTech does not feature any additional features such as launch control, shift control, or boost control. It does have an AUX output which can be used to switch an item at a certain rpm, temp, boost etc. The system does need to be wired into the vehicle and MicroTech air and water temperature sensors need to be installed. The MicroTech uses the additional sensors for its correction factors changing air fuel ratio and timing etc. The MicroTech is an engine management computer that controls basic engine functions (e.g. fuel, ignition, and timing). The simple design with good use of technology and good tuning software makes the MicroTech a very efficient and accurate engine management tool. This combined with its cost, results in it being a very good engine management option. Pac uses this ECU to do 7.6sec ¼ miles.

Motec M48 Pro

The Motec is tuned using a laptop and the Motec software. It has very involved tuning facilities which enables extremely fine-tuning to be carried out. Tuning time and in turn costs can be greater than most other systems as the Motec is a more involved management system with many adjustments. Motec also offer a Motec digital dash to monitor engine functions. The Motec processor is 32 bit and 25 MHz, making it extremely fast, easily the fastest discussed in this article. The high processor speed is not entirely utilised for basic engine control; the extra speed comes into its own when the additional option of advanced functions is chosen. The Motec without the advanced functions option does not have launch control, boost control, NOS control, data logging, traction control etc, and these options are often expensive. With the advanced functions activated all these functions are then unlocked from the computer and can be utilised. Using and setting up the advanced functions requires more time, and so involves greater expense. The system does need to be wired into the vehicle and Motec air, and water temperature sensors need to be installed. The Motec uses the additional sensors for its correction factors changing air fuel ratio, timing etc. The technology used in the Motec is top of the line, resulting in a very powerful engine management system. Motec is considered by many to be the Best engine management brand in the world, but it does come with a price. With Motec the results speak for themselves, so many of the top cars

like Heat Treatments Skyline and RSL's Integra run one. The advantage and cost of the Motec for most when compared to the cars budget, application, or modifications will be too great. This is a system aimed at the large budget vehicles where all features may be required. A Motec can do it all, and if you swap cars, you can take it with you as it can be used on anything. It is not the worlds best ECU as there are others out there that are better, however, they're worth upwards of \$30,000 dollars. All of a sudden, Motec seems cheap.

Apexi Power FC

Apexi Power FC is purpose built for each vehicle model and is a direct plug in. Tuning software for each model is not always available for laptop, but Apexi have a hand controller, which is usually utilised during the tuning stages. The hand controller requires many screens to be cycled through before a parameter can be altered before having to return to the original screen for monitoring. The laptop software could reduce time lost cycling through menus. Apexi features a high-speed (up to 32khz) 16-bit processor, and launch, and boost controls are optional. The Apexi is a straight plug in, and uses factory sensors, so no additional sensors will usually be required to be fitted. The Apexi is the first and in many cases the cheapest option when it comes to upgrading a vehicle engine management and the factory computer is not re-programmable. Often used in R33 Skylines, Evo 4-7, Series 6 RX7's, Supra's etc, the Power FC is a cost effective alternative for some vehicles which require a fully tunable computer, Apexi however do not cater for all makes and models so are subject to availability. Performance is good with the plug in program being able to run the vehicle straight away, albeit not safely under load. Fine-tuning can then be carried out to get the ideal tune. Caution must be taken with the plug in tune, as it is often too advanced and lean.

Link +

Link can be tuned using either the Link hand controller or the Link laptop software. The computer offers a simple straight forward tuning which saves on tuning time. The Link utilises an 8 bit 12mhz processor to monitor engine functions, and comes with an array of extra features. Extra features such as shiftlight output, water sprayer control, launch control, shift control and anti-lag. The system does need to be wired into the vehicle and a Link air temperature and water temperature sensor needs to be installed. The Link uses the additional sensors for its correction factors changing air fuel ratio, timing etc, but does not have a correction for barometric pressure. The Link offers more features per dollar spent, but at the same time has the slowest processor of all the systems looked at in this article. Given this fact, one may be dubious as to how well the additional features can be operated by the system.

Hondata S200

Hondata systems are made to incorporate with factory Honda computers. Installation required is minimal so they are inexpensive to install. Tuning of the Hondata is done using laptop software. The system utilises the factory Honda processor that is 16 bit and 16mhz. The Hondata uses factory sensors with the only addition being a clutch switch if launch control is to be used. The standard S200 Hondata system is fully tunable with, vtec control, launch control, and shift control. The options for boost capability can be

added as well as fantastic data-logging software. Hondata is a Honda specific computer that is very cost effect and purpose built for Honda applications. Performance is very good as utilising factory built computer and simply building on what is already very good factory computers. Hondata is so good that the world's fastest allmotor (10.2sec ¼ mile) runs it.

Proper installation and tuning of any aftermarket computer system is essential for the correct and safe operation of the new setup and is required to gain the optimum performance from the vehicle. Any computer system is only as good as the tune it receives.

Installation of many of the systems detailed is very straightforward and inexpensive. Apexi Power FC, are all straight plug in replacement computers to suit the vehicle. Link and Motec also offer plug in options for a number of vehicles.

Vehicle tuning is a trade all of its own that when done correctly requires the use of a number of additional tools.

Monitoring equipment such as the knock monitors and the Air Fuel Meters allow the tuner to adjust the air fuel ratios and the timing to prevent engine damage through detonation. This can be carried out without sacrificing on engine performance from the engine tune being too conservative in an effort to eliminate detonation when the limits can not be found due to lack of correct or unreliable information.

Knock monitors are used to detect engine knock or detonation during tuning, Knock in many vehicles is not audible and requires a specialized sensor. The sensor will indicate to the tuner that the engine is knocking or detonating and action needs to be taken to rectify the problem. Knock monitors can be audible items where as the tuner will use headphones to hear the knock, or a visual knock meter, which registers the amount of knock on a meter.

Air Fuel Monitor is a critical tool for any tuner. The oxygen sensor used during dyno tuning is much more sophisticated then the item used by the car factory. The items used during tuning monitors the air fuel ratio more exactly and faster than the standard item. The air fuel ratio of a car is critical to an engines performance. If the air fuel ratio is too low then the mixture is too rich and will rob the vehicle of power.

A vehicle running rich may be obvious from the presence of black smoke being blown from the exhaust, caused through unburned fuel. Spark plugs will foul easily and will appear black and clogged. The extra fuel can result in carbon build up on the piston or else where in the combustion chamber. These deposits can form hot spots, which can cause pre-ignition resulting in detonation or knocking. A vehicle running very rich can result in the bore being washed in fuel. The excess fuel then flows down the bore past the piston and washing the oil from the bore, removing the lubrication and protection provided by the engine oil resulting in the extra wear. The excess fuel will also contaminate the oil and result in poor oil performance throughout the engine.

On the other hand there are vehicles that may run air fuel ratios that are far to high, which result in the car running lean. Lean running motors are more common place due to people running extra boost for example and not having their fuel system modified to suit. As an engines air fuel ratio becomes higher the combustion chambers temperature also

increases. This increase in temperature combined with the increasing chamber pressure due to the piston rising can result in the fuel being pre-ignited. This explosion is commonly referred to as detonation and it can in many cases be heard. Detonation can produce pressures in excess of 6 times the normal combustion pressure. It is the early explosion or detonation due to a too lean mixture that can result in sudden and extensive damage being done to the motor e.g. Snapping rods, cracking pistons, braking crankshafts.

This damage is done due to the early explosion forces against the upwards motion of the piston, the piston continues its upward stroke against the explosion due to its momentum and the crank forcing the piston up as the crank revolves in its cycle.

Detonation can also be due to hot spots in the combustion chamber where an area of the cylinder wall or top gets hot enough to ignite the fuel waiting in the cylinder; pre-ignition resulting in detonation. Hot spots form in positions where perhaps poor machining or design has resulted in an area that is exposed to excessive heat without enough heat conduction capacity available to dissipate the heat efficiently. This can result in the temperature getting high enough to ignite the fuel prior to the spark.

Detonation caused by hot spots or carbon deposits can be removed through tuning although this means very retarded timing and rich fuel and hence a large loss in power. Correct tuning is critical for the performance of any vehicle. It is in the tuning where the power will be gained or lost, and this can ultimately determine how long an engine is going to last. The processing speed or accuracy of the engine management system used can limit the tuning results. In a high performance highly stressed motor slight variations in air fuel mixture or the computer not updating timing fast enough will result in lost power and potentially damage to the engine.

It is for those reasons that top competition cars whether for drag, or circuit use advanced and more expensive engine management systems. The more expensive advanced systems offer better control over engine functions and have a greater processing speed, meaning that the data from the engine sensors can be recognised and acted upon much faster than slower systems. An example of why a quality tune combined with fast engine management is important can be shown by the power that can be gained or lost, due to the tune or a computer not correcting timing, fuel, or ignition fast enough. 2 degrees of timing on a Vtec turbo at 20lb can mean more than 30kw at the flywheel. The problem is how to tell if those 2 degrees will make it, or break it. This is why it is best to have the vehicle tuned under controlled conditions, using a management system that will respond quick enough to make the correct adjustments resulting in the desired power figures, and not the undesired engine rebuild. The tuning environment will impact on the power characteristics of a vehicle if the conditions are not kept constant. Accurate dyno tuning requires consistency, so slight changes to the vehicle tune or setup can be measured by the dyno as a gain or a loss.

Engine management needs to be a serious consideration when modifying a vehicle. Investigation should be made into whether the factory ECU can be fitted with an off the shelf chip or if a custom chip can be produced to suit the vehicle. If you choose to go for an aftermarket computer then choose the system carefully, and investigate your options to make an informed decision so not to make a costly mistake.