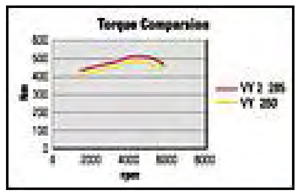
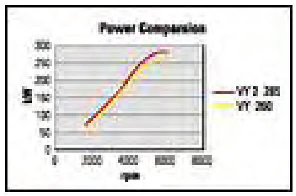
Management Man

Talking to the man who maps the engine management systems on HSVs.

by Julian Edgar


Torque Comparison
600
500
400
300
200
100
0
0
2000
4000
6000
8000
rpm


285



The Holden Special Vehicles VY Series II range of cars feature outputs upgraded to 285kW at 5800 rpm and 510Nm at 4800 rpm, with the torque increased right across the engine rev range. To make these gains, the 5.7-litre V8 uses a redesigned lower air box and intake ("zip") tube, and new 4-into-1 exhaust extractors.

So nothing wildly exciting about any of that - just some breathing enhancements of the sort performed by many aftermarket workshops.

But as is the case with all HSV cars, the engine management has also been custom-tuned to suit. And it's in this area where the level of released detail is usually scant - until now. Recently we spent time with HSV's engine management guru (and HSV VY series II Program Manager) Sam Davis, talking to him about management mapping.

One of the most interesting points that he made was that the new design of extractors on the 285kW engine has a major side benefit - the removal of heat from the combustion chamber.

"If you have a better design extractor, you get the gases out - but you also get the heat out," he said. "Up to 3000 rpm, most of the power gain is because you can therefore put more spark advance in. You also don't have nearly as much power drop when it's hotter."

Normally, a deeper breathing engine will see some changes made to the ECU maps to cater for the improved volumetric efficiency - if the engine breathes better, it will need more fuel. But with an airflow-metered engine like the Gen III (LS1), surely the system will simply measure the extra air and provide more fuel to suit?

"It's not quite as simple as that," Sam said. "It's complicated to some extent because part of the software these days uses torque-based modelling. This means that certain parameters are deduced and so your model's got to be pretty accurate. There's actually a Volumetric Efficiency part of the table and you've got to fill those numbers in."

Sam said that for the new range of engines, all the volumetric efficiency data had to be redone by HSV.

Torque-based modelling is widely used in the engine management systems of engines that use electronic throttle. However, the local Holdens still use a mechanical throttle. So where does that leave the modelling?

"This engine management system is a hybrid one, which has still got a mechanical throttle but uses some of the torque modelling [software] ," Sam said.

So, is a major function of that torque-based modelling to protect the engine? The idea that with this engine, power gains made by bolt-ons are lost as the system works its way back to the standard power output?

"Not through the torque modelling - but there are other things that will look after it. Say you put a VYII exhaust system on, but leave the VY calibration. Effectively, things are going to be a little screwed-up. You'll be on a different part of the table than it thinks you're at, but because that part of the table isn't really significantly different, it isn't going to make a huge difference. It's just not optimised.

"The system has some learning ability - for instance, the spark system has a learning ability built-in. With the Delphi system you have a low octane table and a high octane table. As you're driving along, the knock sensors may be hearing knock, and they'll send a message to the system to start learning away from that point.

"So what can happen is if someone's done some [mechanical] changes, you might find that at wide-open throttle you don't have any knock because it's running fairly rich. But when you drive the car, it might learn away from that point because the knock sensor's picking up knock and learning back down to the lower table."

This can then result in an initial post-modification dyno run that looks really impressive - but another performed a week later may be down in power. Sam said the knock sensor is listening at all revs and loads, but the system doesn't learn at all combinations. But when the system is learning, it has the ability to pull the whole ignition table back, so affecting the ignition timing at all loads.

"Even that's not quite true. There are modifiers within the calibration that say 'if you're at this revs, make it change by 80 per cent of this difference; at this revs, 50 per cent; at this revs, 20 percent.' "

In other words, there is a lookup table that specifies where the timing moves between the low and high octane tables for a given amount of knock at each engine speed. But since we've been able to hear detonation in many HSV models that we've driven (especially after heat-soaking the engine), doesn't this mean that the calibration is wrong, irrespective of the ignition timing learning?

"In practice there are so many variables that it's very hard to cover absolutely every single combination. Holden tend to be very conservative; they feel that the customer doesn't want to hear any knock. But we [at HSV] prefer to push it up a little bit further because we believe that our customers would prefer to have the performance and have an occasional ping when the system isn't quite quick enough.

" [But] you can do work in the calibration to fix that. In a heat-soak situation there's another modifier in the calibration that pulls out a certain amount of spark, depending on the intake air temperature. But if you take out too much, you've got a flat spot and no power."

In addition to running more ignition advance, the HSV models also use leaner full-load air/fuel ratios. These result in higher combustion temperatures - so how can HSV take a bigger risk in this area than Holden?

"The most important factor is catalytic converter protection. Holden have close-coupled catalytic converters for VYII, but we haven't. We use a big cat so we can push it back [down the exhaust] a bit.

"The maximum allowable temperature of the cat is 850 degrees [C] . Even on a coolish day, if you use wide-open throttle, it's amazing how quickly it rises. At WOT the cat temp will reach 850 degrees by the time you reach 100 km/h. As soon as you get to that threshold, you've got to richen-up the mixtures to try and bring that cat temperature down.

"Because the engine management system doesn't measure the temperature of the cat, this is one of the model-based parts of the calculation. It looks at the amount of time that you've accelerated, at rpm - at a number of different variables - and calculates what the cat protection mode should be.

"Because of the design, our exhaust runs cooler and we don't get to that threshold as quickly - and when we do get there, we don't have to put as much fuel in. So in terms of cat protection, we're actually taking no further risks."

With the cat converter mounted further from the engine than in the Holden models, doesn't this cause start-up emissions problems as the cats take longer to come up to temperature?

"We're starting to have to do a couple of little tricks to get past Euro II emissions. There's a little bit more spark retard on start-up than we had before and idle speed is up a bit, which heats everything up a lot quicker. But it's only really necessary for the first minute or so."

That's start-up emissions, but what about lean-cruise? An engineer at another Australian car manufacturer privately told us that he thought lean-cruise was morally unacceptable - basically a cheat's way for getting good fuel economy with bad emissions, but only activated outside of the Government emissions test cycle. However Sam said that lean cruise was no longer used on Holdens.

"Australian Design Rule 79 specifically says that you can't have lean cruise," he said. "But you're right about when it was activated. When I did it, I put a factor in that said if the car was running at 80 km/h for more than 90 seconds, switch lean cruise on - because it doesn't do that anywhere in the emission [test] cycle.

"Lean cruise means that fuel economy is better, so greenhouse gasses are less - but NOx goes through the roof. But if you think about it, it's only ever going to happen in the country or when you're cruising along at a steady speed. The problem with NOx is that it's bad for your visible emissions because it puts brown smoke in the air, but [at the same time] you're using less fuel and resources. I don't know - it seems to me that there's a lot of good reasons to have lean cruise if it's out of the city limits.

"Anyway, the ADR says you can't have it, so we've switched it off completely."

So what other interesting maps and functions are built into the Delphi ECU?

"Most of it is really just housekeeping - nothing terrifically exciting. Lots of little bits and pieces that are affected by what we've changed. But when we did the Callaway engine, we had to change a lot more [in the engine management system] than with the current engine. With that new throttle body we had to remap the throttle body flow relative to the idle control valve.

"One thing we had a lot of problems with was transient fuelling. If you tip-out [ie get off the throttle] quickly there's a natural reaction for the engine to go rich because you've taken the air away. When you tip-in [ie get on the throttle] there's a natural reaction to go lean, which is why in the good old days there was an accelerator pump to squirt that bit of fuel in.

"That's what a lot of these little [software] factors do - they're modifiers that try to keep your fuelling at a good limit so that you don't get tip-in hesitations. But if it's too much you can bomb-out in emissions - you don't notice it in the driveability, but suddenly you find that your hydrocarbons have gone through the roof. In this software there's even a manifold wall wetting factor - I never got it to work properly, but it's there!

"But the main areas we change are all the basics: the fuelling, the spark, the knock system. Because we have a different signature in the knock with our extractors [fitted] , we have to change the knock sensor calibration. The gases are now exiting differently and the heat's different in there, so you get a slightly different signature in the combustion. With the C4B [Callaway] engine the signature was significantly different and the knock sensor calibration in the C4B is very different to that used in the LS1."

And is recognising the different signature of knock a case of changing what sort of waveform is recognised as knock, or just changing the sensitivity of the sensor? Incredibly, it's the waveform recognition which is changed in the software!

"We don't do it ourselves," said Sam. "We get the guy from Delphi in the US to come out and do it - that's how complicated it is.

"I've been with him when he's done it and he'll be sitting in the back, with headphones connected directly to the knock sensor. He'll have an oscilloscope that's showing the wave coming out of the knock sensor and he'll say, 'Ah! that's knock, so I am going to make it recognise that bit [of the waveform].' Then he calculates what numbers to put into the calibration to mean that the wave has been recognised as a knock wave, not piston noise or something else happening.

"It is amazingly complicated and it takes days and days."

Sam said that the engines don't use cylinder-specific knock sensing, although that is coming. But even though the system listens to all eight cylinders simultaneously, the amount of timing that is retarded when detonation is detected isn't the same across all eight cylinders.

"We know through testing which cylinders are more likely to cause a problem than others - it's the middle ones. When it retards the spark, you take it out of those cylinders a bit more than the others."

Factory engine management systems have never been so complex. When you consider HSV is just fine-tuning the management software to suit their modifications, the mind boggles at the thought of mapping a brand new engine from scratch....