fasttech

Words: Stewart Sanderson
Photos: Michael Whitestone, Stewart Sanderson

WHAT IS MAPPING?

PART 2 We've shown you the basics, now we look at what's needed to perform a live map on your Ford.

Having worked as a tuner for 17 years, Stewart 'Stu' Sanderson is one of the most-respected names in the business.

A Level 5-trained fuel-injection technician, in the past Stu has worked for a Ford Rallye Sport dealer, a well-known fuel-injection specialist and various tuning companies.

Then seven years ago he joined forces with Kenny Walker and opened up Motorsport Developments near Blackpool (01253 508400, **www.remapping.co.uk**), specialising in engine management live remapping, as well as developing a range of Evolution chips which are now sold all over the world.

He's also jointly responsible with Webmaster, Petrucci for www.passionford.com. Started in 2003, it's grown rapidly from a few friends contributing, to one of the biggest Ford communities on the web.

Stu's enviable knowledge of the workings of modern-day Ford performance engines means that every month he's just the man to explain how and why things work, and most importantly how they can be improved.

I HOPE you all absorbed and enjoyed last month's feature on mapping: why you may need it and the various different ways it can be performed. This month we will concentrate on the ultimate form of mapping, and reading last month's feature you will hopefully already be fully aware that it is called live mapping.

The first requirement for live mapping that some people don't in fact realise, is that we must actually have the car in our possession to live map it. Just the ECU is no good at all, as we need to actually have your ECU connected to your wiring harness and have it running your engine as normal, albeit with all our emulation equipment hooked into it as well. This allows us to literally drive your car and alter your management's calibration maps at the exact same time.

So, with this in mind, let's first of all look at how we would interface our specialist hardware with your car to enable us to go out and make a good job of the live mapping...

CHECK UP

First of all, we have to check your car is actually roadworthy, and yes, this means it must have current tax and MoT, brakes and suspension that appear to actually work and fluid levels that are at least somewhere near the full line. It may well sound like I am joking here but I have had to turn cars away on each and every one of those simple points... Sad, but very true.

Presuming your car is actually fit to be driven on the Queen's highway, we must then proceed to load your car up with various forms of monitoring and adjusting equipment, so let's look at this equipment first of all so you can understand the role of each item of equipment and why it is required for the job in hand.

Wideband AFR monitor: essential for live-mapping on the road

WIDEBAND AFR MONITOR

This is the first and foremost part of any tuner's tuning arsenal. You simply cannot tune cars live on the road without one. This gauge allows us to monitor — via a sensor fitted into your car's exhaust system — exactly what air/fuel ratio your engine is running under any condition or load we like. Be it a light throttle fuelling error or a deadly wide-open throttle lean condition, this system can analyse, display and record the information on screen with a response time of under 150 milliseconds.

There are various different types of these monitors available, and quite recently the tuning market has been flooded with affordable units, some good and some not so good.

The one that we use is the industry-standard ECM unit and costs over £6000! It is however, accurate to within 0.06 per cent and can read from as rich as 6:1 AFR to as lean as 150:1 AFR a specification level which virtually no other equipment currently on the market can claim. It's the best, and that's why we use it.

DETONATION CANS

These allow us to monitor an engine for a condition known as detonation. Detonation, as many of you will know, is the biggest and most common killer of modified engines... Period. There are many conditions common in a tuned engine that can lead to detonation, the most common three reasons being:

1. Too much air and not enough fuel (known as running lean).
2. Poor fuel quality.
3. Too much spark advance.

Detonation makes itself known as a pronounced crackling sound. It is almost impossible to describe, but suffice to say that it normally requires some specialist monitoring equipment to hear it properly once the engine is under load. This equipment comes in two main forms: manual and electronic.

MANUAL: This system works just like a mechanic's stethoscope. A sounding tube is bolted to the engine and the ear defenders, connected to the sounding tube by a hollow pipe, are monitored in the passenger

BEFORE STARTING...

The first rule of working on cars and using tools of any kind is don't ever skimp on decent protection. Goggles, gloves, ear defenders, masks and a set of overalls should be in your garage. Use them.

When using power tools, protective gear is essential — grinders and welders can make a real mess of your soft skin and bone if you get it wrong.

Never work under a car without supporting it using axle stands. A car falling on you is not something you'll be laughing about down the pub.


Det cans are basic in operation, but still do the job well

compartment. This system is surprisingly efficient and is still used by most professional mappers.

ELECTRONIC: VERSION 1 — DET CANS

These systems work the same way, but instead of using a sounding tube and pipes they use microphones and wires. A benefit of this system is that you have more than one pick-up so can mount the receptors more easily and often in a few good places, and then choose between the pick-ups in the passenger compartment at leisure.

ELECTRONIC: VERSION 2 — KNOCK SENSORS

This system works by placing a knock sensor (a sensor tuned to the sound of knock/detonation) on the engine, coupled to an electronic receiver with lights on that is placed in the passenger compartment.

These systems are tuned to operate only in the frequency most commonly out-putted by detonation and if it senses an abundance of this frequency, to activate whatever system it uses to warn you. The problem with these is each engine needs the sensor in a unique place to work properly, and sometimes a given sensor will never work properly on a given engine type. But still, we use this system where we know it's of use.

VACUUM AND BOOST GAUGES

Self explanatory to most, but if you haven't come across one before, a vacuum gauge simply allows us to monitor the vacuum or pressure within an engine's inlet tract. A 30 psi boost gauge is normally sufficient for most turbocharged cars but we do have one that goes to 40 and one that goes to 50, just in case...

ECU DATA MONITORS

Again, there are quite a few different types of data monitor and datalogger used depending on the car's management, but since this is a Ford magazine I only need to really describe the two main ones we use for your fast Fords.

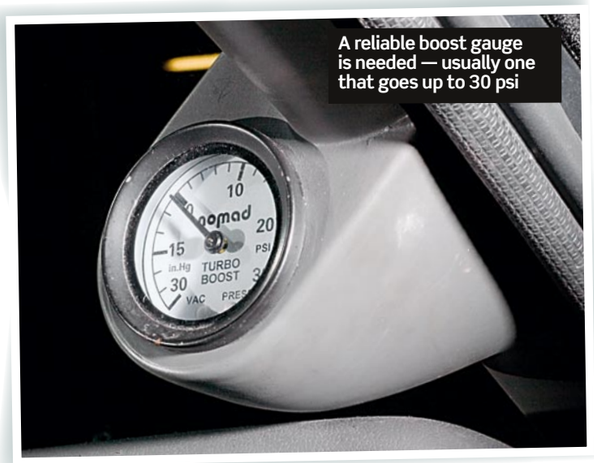
For 95 per cent of Ford cars we have the Sun Scanner. This system allows us to monitor in real time various parameters such as:

RPM (normally measured via crank position sensor)
Battery voltage
Air temperature in both degrees C and volts from the sensor
Water temperature in both degrees C and volts from the sensor
Fuel temperature in both degrees and volts from the sensor
Throttle position in both degrees and volts from the sensor
Mass Air Flow in KGPH and volts from the sensor
Manifold pressure or depression in real values
Lambda voltage output
Injector opening time in milliseconds
Spark advance in degrees of crank rotation
Open/closed loop operation
Fuel pump drive electronics
Idle valve duty cycle
Boost valve duty cycle
Knock sensor activity
Vehicle speed
Adaptive management deviation (more about this later)
And much, much more

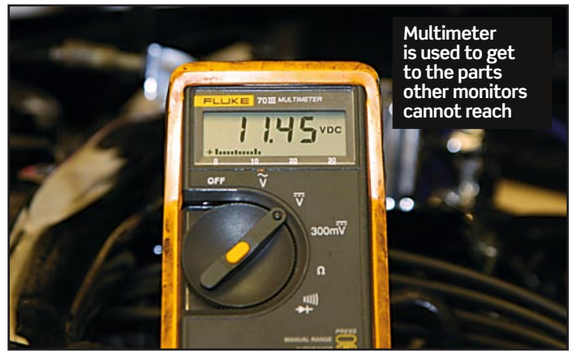
We can also view and graph all this data on the laptop if required, so of course we can datalog and read the info retrieved back at base.


Various ECU monitors are used including Sun Scanner...


...plus the IAW monitor, which works with Cosworth ECUs


A reliable boost gauge is needed — usually one that goes up to 30 psi

Both monitors can datalog vital info. This is from the Sun Scanner



Multimeter is used to get to the parts other monitors cannot reach

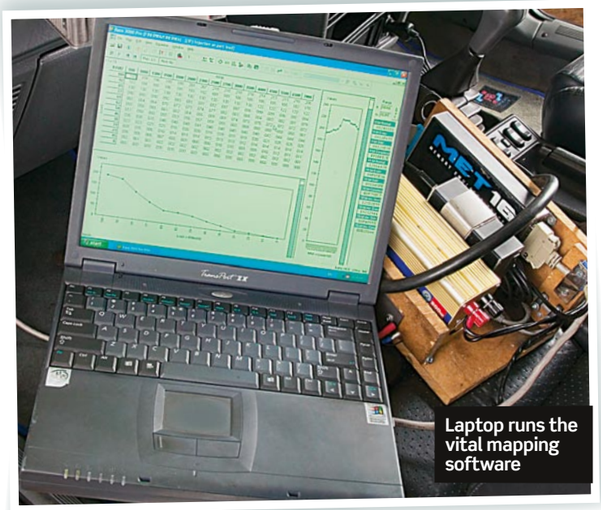
For Ford Cosworth/Marelli systems we have our IAW monitor. This system allows us to log many parameters and monitor for fault codes. It doesn't do as many channels as the Sun system does for the Ford EEC system listed above simply because the Weber system is far cruder and doesn't physically have as many sensors and features, but it does have as many sensors as the management actually has, and you can't ask for more than that, can you? It also does datalogging so we can record all the data and play it back with a brew in the workshop. Bliss...

MULTIMETER

Most of you will be familiar with the common-or-garden multimeter I'm sure? If not, it is essentially a device used for monitoring things such as voltage, resistance, current, impedance, things like that, and the more you pay the more features and accuracy you get. We use one to hook permanently into parts of the car our scanners don't give us information about.

On many old turbocharged Fords we hook the system into the fuel pump feed so we can monitor the power supply at the pump itself. This has saved many an engine and we find it very common indeed that some fast Fords at full chat have got sub-10 volts supplying the pump due to old wiring problems!

So, as you can see, we have a real good picture of what's going on in a modern Ford management system once all our equipment is connected up to its heart... but there is more to come. This equipment has only allowed us to monitor what's going on with the engine and its fuel system, and we fit this lot just even when a car's in for a simple set-up in most cases. The actual live-mapping equipment is the real star of the show and that comes next...



Laptop runs the vital mapping software

LAPTOP

You all know what a laptop is I'm reasonably sure? If not, it's basically a personal computer, in a small enough package it can sit on the top of your lap. This is loaded with software that interfaces all our equipment and allows us to do the mapping. It's our electronic version of a screwdriver and spanner set once the tuning begins.

DC/AC CONVERTOR

This is becoming a common item nowadays, but it wasn't back when we started mapping and I remember paying silly money for our first one. It simply allows us to plug equipment into the car that runs off mains voltage normally, such as laptops. It converts a 12 volt DC supply from your car's battery into a 240v AC output to suit household equipment.

G-METER

This is a unit that can, amongst other things, display a constant G reading. Why would we need this you may ask, well, simply because sometimes it's hard to tell if something you're doing is having the effect on power you think it is, so we can take a look at the G we are pulling in say, fourth gear from 30-70, and then do tests with various things to look for improvements in physical pulling power. More G pulled on the same piece of tarmac in the same direction equals more power at the wheels. A very handy tool indeed.

EPROM EMULATOR

The star of the live-mapping show. The emulator is the one part that you simply cannot access OEM ECU data live without. What it actually does is quite complex to explain, but bear with me and I will try.

In 95 per cent of your OEM ECUs there will be an EPROM. This EPROM contains all the calibration data that your ECU uses to run the engine. All the information about spark advance, fuel duration, idle valve programming, cam timing and boost pressures etc is stored within this EPROM and the ECU can, and does, access it at any time it likes to withdraw the information it requires to do its job. Now the EPROM emulator does pretty much

Left to right: DC/AC convertor, power back-up, all-important emulator

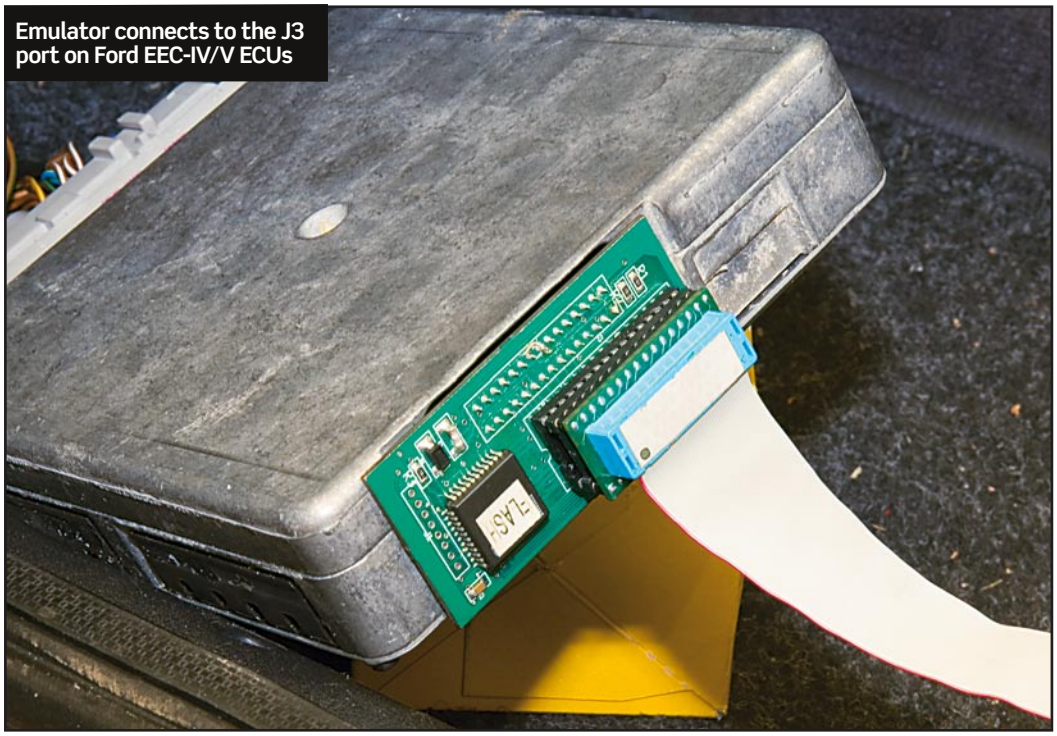
what it says on the tin — it emulates an EPROM.

It basically takes the place of the EPROM and by plugging the emulator into the EPROM socket in the ECU via a special cable and plug we can then load the contents of the EPROM into the emulator hardware from our laptop which allows it to then feed the EPROM contents back into the ECU via the socket the ECU thinks has still got an EPROM in, allowing the ECU access to it as normal. As far as the ECU is concerned the emulator is just the same old EPROM it has always had so it runs as normal.

The reason for using an emulator and the benefits that it brings us as mappers are simple. The EPROM data is now stored within an ultra-fast holding area instead of on an EPROM, this means we can now access that calibration data with our laptop and mapping software at the same time as the ECU accesses it. Not only that, but we can also change it without any form of delay. If we want to change the idle spark value from 16 degrees to 20 degrees, we simply highlight the '16' in the spark table and type '20'. The engine is now idling at 20 degrees; it is as simple and as fast as that.

The next strong benefit of an emulator is the fact it not only emulates an EPROM, but it also shows us what part of the data is being accessed at any time. This is what gives us the ability to change data at the exact same time it is being accessed. Not only that though, being able to see exactly when and what data is being accessed gives us a real strength when trying to find a table in an EPROM that isn't already documented. I will cover that more later, but suffice to say it's virtually impossible to do without reverse engineering the software unless you have an emulator to hand.

Finally, the emulator we use has another two clever tricks up its sleeve. Firstly, it's a twin system that allows us to store two sets of EPROM data within it, and as a result we can swap between these two calibrations at the flick of a key. Why would we want to do this? Well, various scenarios would make this system worth its weight in gold.



Emulator connects to the J3 port on Ford EEC-IV/V ECUs

The first of these is this: imagine that you wanted to test an engine with two different types of map, say one aggressive and one soft timing map. We can do one run with calibration one, flick a key and then do an identical run with the second calibration. No dismantling, and no messing, just press a button and you have a whole new map in the ECU.

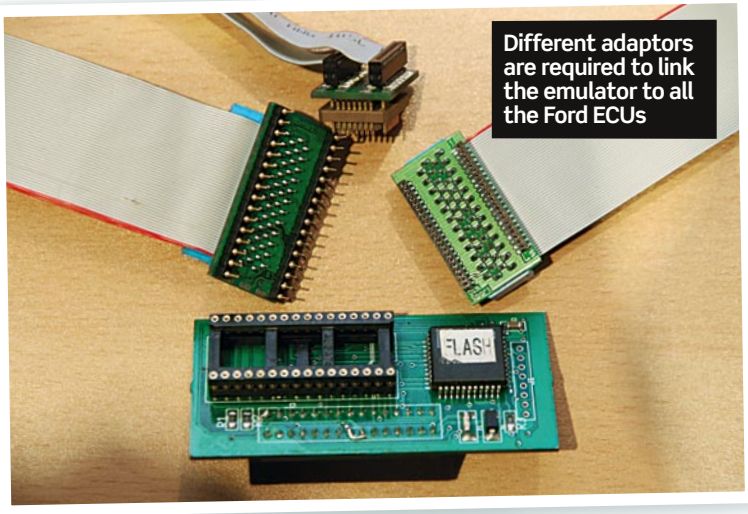
Another reason the twin calibration emulator is better than a single is that we are able to store a known good map in the emulator in bank one, while we map a new one in bank two. If we were to make a mistake and for argument's sake deleted half of a fuel map by accident, leaving us with a no-run situation on the motorway we can simply press a key and we have a perfectly good map running the engine again while the mapper gets to work fixing his error.

It's also common you would load the old map into the first bank which allows us to keep swapping back to ensure our new map is an improvement on the old in terms of power, progression, driveability, fuel economy etc, and in many cases we would use it to ensure a customer's specifically-named mapping problem is ironed out, such as hesitation as a car comes onto load or things like that. We can go back to how the car was before we started mapping, just to remind ourselves where the problem was and what it felt like.

Remember I said the emulator has two more clever tricks up its sleeve? Well the second trick is that it has its own power storage unit that basically works as a battery back up unit.

If for any reason the laptop was to die, or a cable become unplugged, the emulator's power storage unit would power the emulator for long enough that it could continue to feed the calibration data to the ECU for a few hours, allowing us to drive back to the workshop in safety pretty much no matter where we were in the country. That is a godsend in terms of safety and reliability, especially as me and laptops never seem to get on for any long periods of time...

So, that's about it, all the monitoring and adjusting hardware is actually in the car now so all we have to do is connect the emulator to your ECU so it can do its emulating bit and we are ready to access all the information within it. The Emulator connects in various ways, depending on what Ford you actually have...



Different adaptors are required to link the emulator to all the Ford ECUs

FORD EEC-IV/EEC-V ECUs

This system is connected up via the J3 port on the rear of the unit. It just plugs in once we have cleaned up the port to remove some moisture-proof grease that Ford added to it. Some later ECUs require a small link soldering within the ECU's case to enable the port, but other than that it pretty much just plugs in.

WEBER-MARELLI ECUs

The Weber ECUs are even simpler. They all contain one form or another of 28-pin EPROM, and the emulator has a 28-pin adaptor that takes the place of the chip. Unplug the chip, plug in the converter lead from the emulator, start up and go.

There are a few other ECUs used in Fords, especially the newer diesels, but the above two are the most common ones as far as 98 per cent of you are concerned, so we won't go into any detail about the others. In fact, this month we wont go into any more detail about anything at all as we have run out of space...

NEXT MONTH

The art of mapping: what we do and why we do it. Plus how we find maps in new ECUs we have never seen before and the difference between different mapping programs for OEM systems such as Ford's EEC and Weber's IAW series of ECUs.