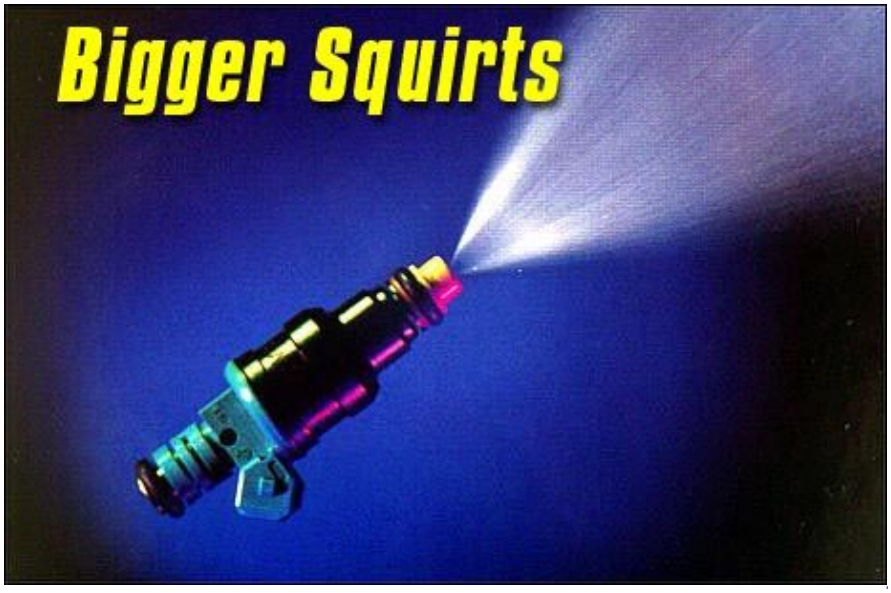

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DIY Bigger Squirts

Fitting bigger injectors

By Julian Edgar

If an EFI engine has been given a major increase in power, the chances are high that the injectors won't be able to flow enough fuel to meet the new demands. This will result in lean mixtures and the possibility of engine damage, along with less power than you could otherwise expect!

With so many EFI cars around, picking up cheap, larger injectors is easy. But if you then have to get a special new airflow meter or Electronic Control Unit to suit the injectors, you could be up for big dollars. But what if we told you that you can probably run the bigger injectors using electronic mods costing under A$10? We thought that you'd say that!

When You Need Bigger Injectors

Normally, the injectors are open for only a small proportion of the time. An injector open for a quarter of the potential time is said to have a 25 per cent duty cycle. If it's open for half the time the duty cycle is 50 per cent, and so on.

When the injector gets to having a 100 per cent duty cycle that's it - it is being held fully open and so can't flow any more fuel. In this situation, new, larger injectors will need to be fitted. It's true that you can lift the fuel pressure to squeeze more fuel through the standard injectors, but this is okay only for small fuel flow increases.

Measuring the injector duty cycle at max power will show when larger injectors need to be fitted. Here at idle the duty cycle is only 1.4 per cent!

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So how do you measure the injector duty cycle?

Some automotive multimeters can measure injector duty cycle if the injector connectors are back-probed. You need to do this at max rpm and full load to see the max duty cycle that is being used. If the meter reads 100 per cent, get new injectors.

Picking New Injectors

When making injector swaps, the resistance of the old and new injectors should remain very similar. Measuring the injector resistance can be done with any multimeter.

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When making injector swaps there are a few aspects to keep in mind. Firstly, the new injectors need to have the same coil resistance as the standard injectors. This resistance value can be measured with a multimeter. If the readings are, for example, 13 ohms versus 14 ohms, this small variation will be tolerated by the ECU without any problems. However, replacing a 16 ohm injector with a 4 ohm unit wouldn't be on.

Secondly, it helps a heap if the new injectors are physically very similar to the original units. Machining intake manifolds to accept new injectors is a pain (and expensive!), while the mounting system at the other end of the injector can also vary enough to cause problems.

This means that if you can source larger injectors from another engine made by the same manufacturer, you're more likely to end up with injectors that can be simply slotted into place.

Injectors which are different lengths, have different plugs, and have different mounts do not make for an easy swap! Better to get injectors which are at least similar in shape and size.

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Finally, the increase in flow should be appropriate. You can measure the flow of the new injectors or get someone with an injector flow bench to do this. But it can be pretty hard to do either of these when you haven't yet got hold of the new injectors! Alternatively, you can look carefully at the engine that the new injectors came out of. If you're looking at a 150kW (200hp) six cylinder engine, each of the six injectors can flow enough fuel for an easy 25kW (33hp).

Injector flow can be estimated from total engine power. This Nissan SR20DET has around 150kW (200hp) in standard form. With four cylinders, you know that each injector can flow an easy 38kW (50hp).

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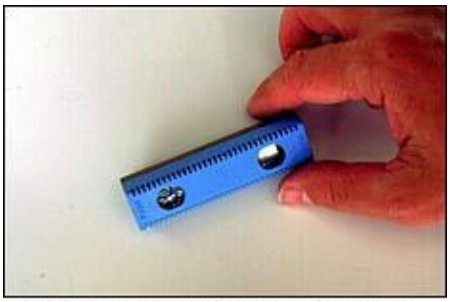
Don't go up massively in flow capability, or the idle and low speed driving may suffer. This is because a large injector loses flow accuracy at the small pulse widths which are required of it at low loads. Some factory cars actually change their injector pulsing to occur only once per four stroke cycle at low loads, while squirting twice per cycle at high loads. In this way, very small pulse widths aren't required at low loads. If you pick a way-oversized injector then there might be low-power problems.

Making Them Work

Once fitted, you need to make the new injectors flow properly to match the air/fuel ratio needs of the engine. It's likely that the air/fuel ratio will now be very rich with the large injectors - everywhere except possibly at max power in a modified engine! This makes sense since at the same pulse widths (injector opening times) you'd expect the bigger injectors to flow more fuel. There at least four different ways around this dilemma.



Getting a chip purpose-written to control the new injectors will give very good results, but it often isn't appropriate for a small budget job.

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Firstly, the ECU software chip can be re-written so that the injector pulse widths match the new injectors' flow. If it is done well, using a good air/fuel ratio meter and working with a computer programmer who understands cars as well as machine language, then the results will be very good. Extensive dyno time is also be a prerequisite and the process is generally not cheap.

The oxygen sensor closed loop feedback will sometimes lean out the mixtures enough to allow slightly larger than standard injectors to be run without any electronic mods at all.

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Secondly - believe it or not - no changes at all may need to be made, especially if the new injectors are only a little bigger than standard. With the oxygen sensor telling the ECU what mixtures are being run in most conditions and with many ECUs capable of self-learning, a good long drive may be all that it takes for the ECU to compensate for the new injectors' flow rate. Unless the car won't even start, try driving the vehicle for a while first. Over-rich mixtures run for a short time won't do any damage, and the ease and cost-efficiency of this approach (if it works) leaves everything else behind.

However, the most likely requirement is that the output of the major load sensor will need to be changed. Depending on the car, this sensor will be either a MAP sensor or airflow meter. If the ECU thinks that there is less load than there really is, it will reduce the pulse width (opening time) of the injectors. This reduced pulse width, coupled with the bigger injectors, means that the right amount of fuel can then flow.

In other words, if the ECU thinks that only enough fuel for 50hp is needed while a demand for 70 is actually required, it will pulse the injectors to provide 50hp of fuel. However, with the bigger injectors in place, enough fuel for 70hp will actually be injected! So, making the computer sense a lower engine load than is actually occurring will straighten-up the mixtures again.

An airflow meter bypass will reduce injector pulse width and so can be used to compensate for larger injectors.

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This computer misinformation can be provided either mechanically or electrically. In an airflow meter car it is possible to place an air bypass around the meter. With less induction air actually flowing through it, the meter will signal to the ECU that a shorter pulse width is needed, and so mixtures will be normalised. Changing the diameter of the bypass will adjust the mixtures.

Doing it electrically is far easier and more cost-effective, though. Before discussing the electrical approach, a few words of warning are required.

- Blowing-up an engine (especially a turbo one) developing a heap of power is as easy as one power run with lean mixtures.
- Mixtures should be monitored by an air/fuel ratio meter. Dong this with the car on a dyno gives the best control over what is happening.
- Start off rich and then lean things out - don't go the other way.

The reason for these warnings is that - with the following approach - changing the mixtures from full rich to full lean anywhere in the rev range is as easy as turning a couple of knobs!

So that you can electrically fool the ECU into giving the right mixtures, you need to examine the pin-outs of the airflow meter or MAP sensor. A power feed to the sensor (usually 5 volts), an earth, and a signal wire should be able to be located. In vane-type airflow meters, an air temp sensor is also used, but you can ignore that. Whether the sensor's output voltage rises or falls with increasing engine load doesn't matter when using this circuit. However, this approach cannot be used with airflow meters or MAP sensors that have a variable frequency output.

This car has had its MAP sensor output modified to run larger injectors. The wiring was done at the MAP sensor itself for ease of access.

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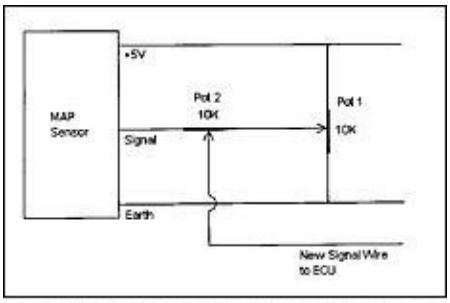
Two potentiometers (abbreviated to 'pots') are used. Both are 10 kilo-ohm linear designs; they cost about A$2 each from an electronics store. A pot works as a variable voltage divider, allowing the central wiper contact to be skewed to one voltage or another. In the circuit used here, one of the pots is connected between the 5 volt supply wire and earth. With this pot's wiper at the 5 volt end, that's the voltage available on the wiper terminal. With the wiper at the earth end, there will be no voltage available. Pot 2 connects between the wiper of Pot 1 and the signal output wire of the sensor. Moving the wiper arm of this pot (which goes to the ECU) will cause the signal to be either closer in level to the sensor output, or to the voltage provided by Pot 1.



Two cheap pots can be used to make the output of the MAP sensor (or airflow meter) adjustable. A similar approach can be taken with airflow meters as well.

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The wiring is simple, and the use of the pots even simpler. To start the car, set both pots to their central positions. Disconnect the oxygen sensor from the ECU, so that it can't go into closed loop mode - this causes constant cycling of the mixtures. Use Pot 1 as a coarse mixture control, and Pot 2 as fine adjustment.

These pots were mounted on a small panel so that they were easy to use.

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Start off by setting light loads. When the light load adjustment is about right, lift the power level required and re-do the fine-tuning using Pot 2. Obviously it's more important to get the high loads right than the light loads, but when the mixtures are set perfectly for high load conditions then they may not be right at light loads because of non-linearity in the engine's fuel needs when compared with its unmodified state. If the light loads look a bit too rich, don't worry - when the oxygen sensor is re-connected they'll lean out as the ECU learns its new mixtures.

This tiny 660cc Daihatsu Mira Turbo runs a big turbo and water/air intercooling. Larger injectors from a Charade GTti are operated by the factory ECU, with two pots on the MAP sensor used as described here. The car screamed out 86kW (116hp) at the wheels - more than 200hp per litre....

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When the mixtures are right, it's easiest to simply glue the adjustment knobs into place so that they can't be changed further.

Readers' Response

There is also an extremely simple method of compensating for richer mixtures in airflow meter'd vehicles, without the need for electronic solutions. Flap door (vane) airflow meters have adjustable spring pre-tension, and hence smaller openings of the flap-door are achievable by increasing the spring tension. This fools the computer into thinking there is less airflow, and thereby reducing the pulse width of the new (larger) injectors.

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