

On The Tools

TECH SERIES...
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Clever tuning tips to get your air/fuel ratio right.

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How to remove broken bolts & get the right torque settings.

Transmoto Expert



WHO DA DOLE?

Nick Dole owns and operates Sydney-based suspension business, Teknik Motorsport. In the past decade, the man has tuned suspension for the Ballard's Offroad team, performed engine and suspension work on Australian Safari-winning GHR Honda XR650s, run a Kawasaki Pro Lites team in the Aussie MX Nats, worked as an independent technical consultant for magazine test programs, and dealt with just about every punter and butchered dirt bike to ever roll into a workshop. We reckon that qualifies him to offer up credible advice about how to get the most out of your spend at the local workshop.

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The engine has no idea what's feeding it. All it knows is that its ideal air/fuel ratio is 14.7 grams of air to 1 gram of fuel.



AIR / FUEL RATIOS

Arm yourself with diagnostic skills so you can feed your motor right.

NICK DOLE

Both two- and four-stroke engines remain fundamentally unchanged since the late 1800s. Sure, they've been refined, made from new materials, and their performance developed massively. But they still need a means to get the fuel into the engine, and the carburetor has fulfilled this role, working under a basic atmospheric principle. Fuel injection then arrived in the 1920s and has largely overtaken carburetors in all but one field – dirt bikes. Until now!

So are the fuelling needs of a carburetor engine and an injected engine different? No! The engine has no idea what's feeding it. All it knows is that its ideal air/fuel ratio is 14.7 grams of air to 1 gram of fuel. This varies from 6:1 for a cold start to 17:1 for super-lean burn economy, but generally, it's

accepted that a ratio in the vicinity 12:1 makes the best power.

So what happens if the engine doesn't get what it needs? A flat spot (or bog) is the result of a mildly rich or lean condition, which is enough to put you over the bars when crossing a log or casing a double. An excessively rich mixture will wash oil off the bore, dilute the oil, and increase engine wear. A too lean air/fuel ratio is more dramatic as it causes the piston crown temperature to rise, which usually means a piston failure or a seizure is imminent.

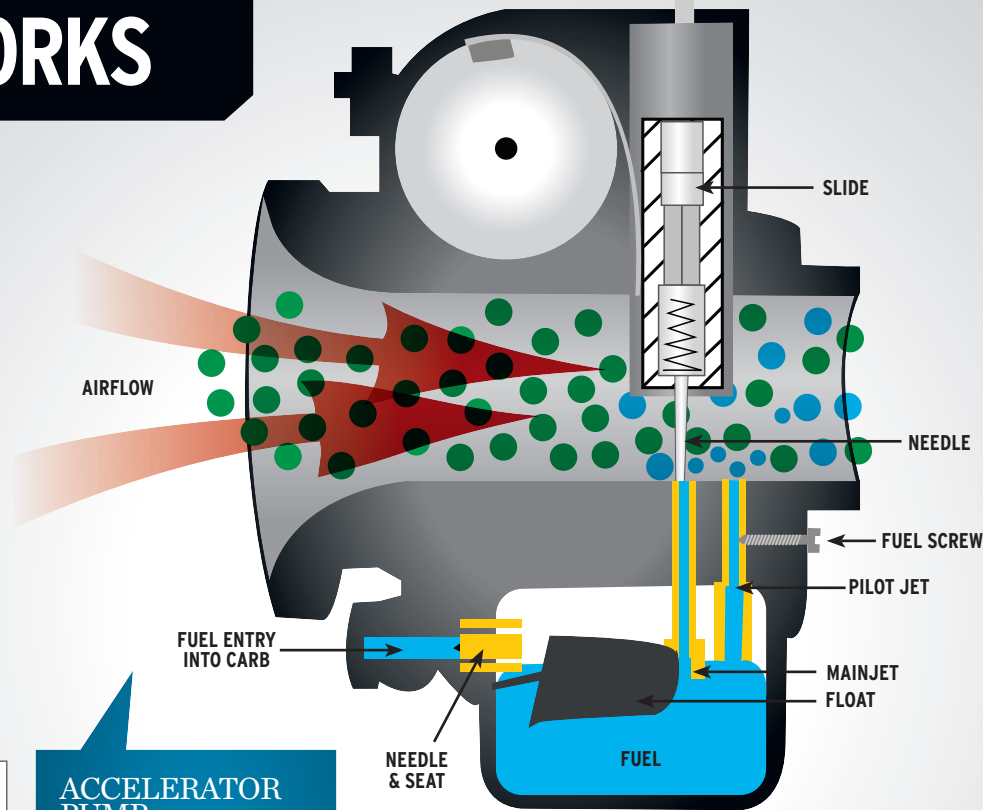
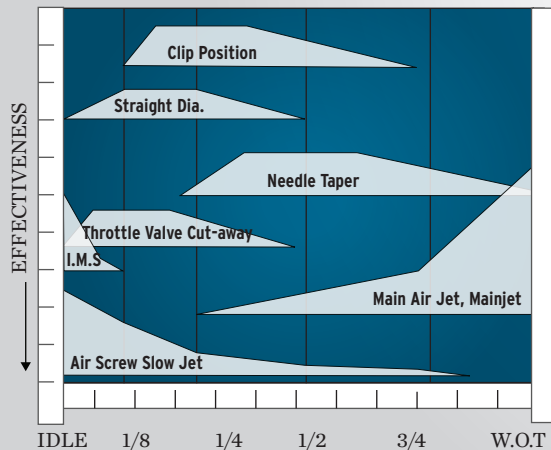
In any case, the consequences can be costly, so it pays to get your engine's diet right. The following pages give you the diagnostic tools to proscribe air/fuel solutions, whether your engine's fed via carb or EFI. ↘

HOW A CARB WORKS

Carburetors all work on the same principles. A venturi, or a narrowing of the carburetor bore, creates a low-pressure zone, allowing fuel to be 'pushed' out of the jets by atmospheric pressure acting on the fuel in the bowl. The most fundamental aspect of carburetors is they are dependant on throttle position, not RPM. So wherever you hold the throttle is controlling the jet that has the most influence.

Carbs come in lots of configurations to suit specific models. In competition-orientated dirt bikes, the slide-type carb is the most popular for its high airflow and power output, while the butterfly-type CV carbs are trailbike low-tech.

The two most prolific carburetor manufacturers are Japanese: Mikuni and Keihin. Of the two, Keihin controls the four-stroke scene on all brands with their FCR (Flat CR). It's a development from a mid '90s superbike carb that has its roots in the 1980s.



ACCELERATOR PUMP

Two-strokes don't need 'em. Four-strokes don't either if you roll the throttle on. As the four-stroke has come back as our preferred engine, some enriching device to overcome the low airspeed and resulting lean condition (bog) was needed. A mechanical pump, linked to the throttle, injects a short shot of fuel while the airspeed picks up as revs rises. The FCR pump system has its own bleed-back jet to control duration.

FLOATS

The fuel height in the bowl needs to be controlled so floats are used together with a needle and seat to regulate flow. Got fuel pouring out of an overflow tube? Either the float level is too high or there is dirt in the seat. A quick tap with a screwdriver handle usually works the dirt loose.

NEEDLE & JET

Mikuni carbs have a needle jet you can swap out as another tunable part. Keihins do it with the straight portion of the needle. There are between five and seven needle clips positions to raise (richen) and lower (lean) the mixture. See the diagrams (left).

COLD-START

Chokes got their name from restricting the intake of the carb with a butterfly, exaggerating the pressure drop and enriching the mixture - essential for cold starting and running. More modern systems are a bypass, sometimes with a separate jet and a means to lift the idle speed while the choke is on. The hardest function for an engine to perform is idling!

PILOT JET

Controls the idle and low revs, usually up to one-quarter throttle openings. It's usually trimmed by a fuel screw or airscrew. To identify which, you have look at where the screw is. If it's before the carburetor slide, it's usually an airscrew, so turning it in (clockwise) shuts down the air bleed to create a richer condition. If it's after the slide, and it's a fuel screw, so turning it out (anti-clockwise) enriches the mixture.

MAINJET

In reality, the mainjet is the last jet you worry about getting right. Its influence starts from throttle openings as low as half, but the pilot, mixture screw and needle need to be right before you get there. Mainjet tuning is the most interesting as it will involve some high-speed runs, often timed between fixed points the find the optimum.

HOW EFI WORKS

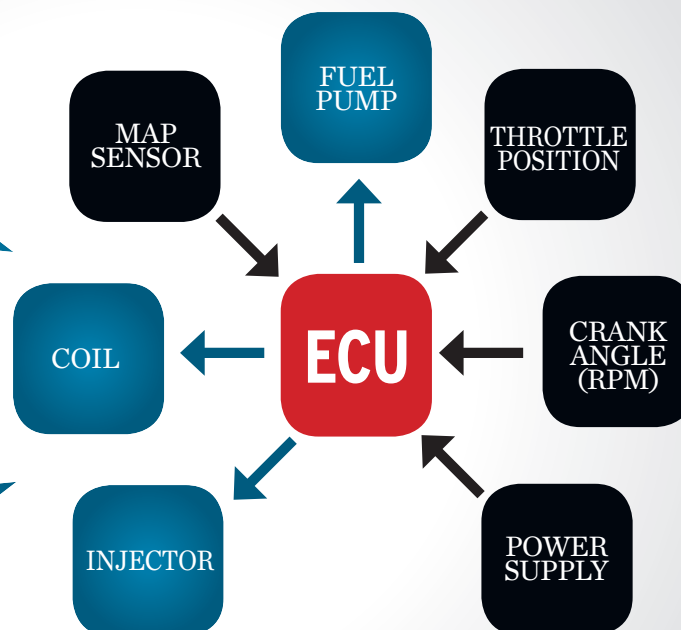
The ECU (Electronic Control Unit) gets a crank signal from the trigger, usually in the left sidecover under the flywheel. From this, it knows what the engine RPM is and where the crank is over 360 degrees, as there are 12-18 "teeth" on the reluctor (the pick-up ring for the trigger). The high-pressure fuel-pump in the tank is driven on start-up by a capacitor (like a battery, but smaller). The ECU gets signals from all the sensors (inputs) and looks at the loaded map for the appropriate outputs, opening the injectors, turning the fuel pump on. The length of time the injectors are open for is "pulse width". There can be single, double or multiple pulses for one engine revolution.

ECU

The "brains" of the whole system is the ECU. All of the inputs from sensors such as engine RPM and throttle position come in and are plotted on 3D mapping to deliver outputs for quantity of fuel-injected spark timing, and when to turn the fuel pump on and off.

SENSORS

The main sensors are crank speed and air volume or pressure (Manifold Absolute Pressure, MAP). With these two inputs, the engine will run. Throttle position, water temp, air temp, crank position, cam position and exhaust oxygen content all add to the accuracy of the fuel delivered.



THROTTLE BUTTERFLY

Unlike our high-performance Keihin FCR's slide, throttle position on current EFI systems is controlled with a butterfly, just like your car. It's a bit down on airflow for a given bore size compared to a slide, so we are seeing some big throttle bodies like the 50mm unit on Honda's CRF250R.

FUEL PUMP

A constant supply of high-pressure fuel to the injector is critical for accurate fuel metering. Dirt bikes are hard on the fuel pump. Dirt and water can enter the pump through the tank or jump landings can jolt it. If the fuel pump fails, the whole show stops. So it pays to be careful when refuelling.

PROs & CONs

CARB PROs

- Everyone knows what it is and most mechanics will pull a carburetor apart.
- Light, robust and relatively easy to tune with a handful of jets.
- Because they are driven by airflow, they are able to auto adjust for blocked air filters, aftermarket pipes and engine wear.
- That damn FCR is very good!

CARB CONs

- Modern frames have meant it's an ordeal to remove the carb to re-jet.
- FCRs are hard to understand for most people with so many circuits, so re-jetting is daunting.
- People pull them apart and don't always get them back together correctly.
- Jets are expensive when you start to have a collection, and you can easily spend a couple of hundred bucks on brass. It's easy to see carbys as old hat when the industry is driven by that shiny new thing.

EFI PROs

- Complete confidence that your engine won't bog on an up-ramp or anywhere else.
- Easy to live with when it's working.
- EFI opens up a whole new world of aftermarket ECUs and notebooks for the tuner in us all.
- No more flooding when you stall it, no leaking fuel in the van as you drive, no vent hoses to get blocked up.
- Ignition and fuel in one neat box.

EFI CONs

- Dirt. It gets into everything.
- The plugs on an EFI harness are very susceptible to dirt and mud.
- Got an EFI problem you just can't fix? Replace the wiring harness as damaged plugs will cause ECU fault codes to be logged.
- EFI is difficult to diagnose when it goes wrong. A flashing idiot light is about all you get without the tuning device.
- EFI can't compensate for engine wear or even a blocked air cleaner like a carby can.

AIR/FUEL DIAGNOSTICS

There is an old saying: "lean is rich and rich is lean". Even the best can be fooled so it's important to listen carefully to your engine before you make a change. However, a change will tell you quickly which way to go. Before you start pulling carburetor apart or reaching for the laptop, fit a new sparkplug, fresh fuel and air cleaner and be sure the engine is in sound mechanical condition.

Typically, a regular rhythmical misfire is richness. The engine feels soft, the exhaust note is mellow. Leanness is characterised by an irregular misfire, an overly sharp throttle

response (even after an initial hesitation) and induction noise. A quick way to check is to pull the choke on; the extra fuel will either help the problem or make it worse, so you know where to go.

Sparkplugs will still tell you a bit of the story, but be aware modern fuels all make the plugs look dark.

The different settings that are loaded into an ECU are called maps because they resemble a 3D terrain map as the throttle position and RPM are plotted on a table. Not to be confused with the MAP sensor!

PROBLEM	SOLUTION - CARBY	SOLUTION - EFI
Won't start - no fuel	Fuel tap blocked, needle and seat stuck	Fuel pump has no signal, ECU won't start pump, dead pump
Idles, but won't take throttle	Pilot jet blocked	TPS not working
Poor cold starting	Too lean, pump the throttle 3 times for FCR	Coolant or air temp sensor fault
Misses at part throttle constant	Straight section of the needle	Blocked air filter or remap
Bogs on up-ramps	Pump timing out or pump too strong/weak	Re-map, low fuel pressure, sensor unplugged
Won't rev out	Mainjet too big or small	Re-map, low fuel pressure, blocked injector
Leaks fuel from overflows	Needle and seat stuck	Fuel line leak
Erratic running, irregular misfire at idle	Too lean on pilot/mixture screw.	Air leak, blocked injector
Misses at part throttle constant	Straight section of the needle	Re-map

COMPARATIVE COSTS

The real bonus of EFI tuning is not pulling carburetors apart on the side of the track. All the factory programming tools will allow a range of tuning, generally 10-30% richer and leaner with not a lot of scope to advance ignition timing into a detonation zone. The tools are all designed to be used by a capable person who has carb tuning experience as the symptoms of EFI mixture are the same as carby's. Some of the tools will allow a selection of maps to be made in the comfort of your shed, then tested on the track as you upload and download maps.

Of all the programming tools, the Yamaha tool is the most accessible at \$399. It does what you need with a few more bells and whistles. The Vortex X10 ECU is worth a mention too at \$799. It has 10 pre-loaded maps and a low/mid/high-range adjustment to make trackside tuning a screwdriver operation.

The danger with EFI diagnosis is replacing the wrong part. If the fault code says replace the

ECU and you do, but the fault code persists, there is no returns on electrical parts for any brand, regardless of what the fault code said. This is where substituting parts from the same model can be helpful as long as you're super-careful with the plugs and terminals.

The difficulty with EFI at present is that many dealers don't have the tuning tools and of those who do, how many of them will be able to offer you an alternative map for your new pipe? There is no aftermarket programming tool that will do all the models, so you will have to look hard for a workshop that has the brand-specific tuning tool for your model and has a dyno or a test facility or have access to good tested maps from the distributors. Experience with Power Commanders (Dyno Jet) on road bikes that download a map from a US-based site is hit and miss as the fuels are different between the countries. Luckily, the mapping on the MX bikes so far has been very good but like all things, there is always room for improvement. ↘

OPERATION	CARB	EFI
Re-jet on dyno	\$250-\$350	\$250-\$350
Diagnose poor running condition or no start.	\$100 will cover most diagnosis.	Find a dealer with the tool, pray it's a simple sensor fault and not a damaged wiring harness. Pay per hour. Don't complain, as it's not that easy.

EFI TOOLS

What tuning tools available for Honda, Kawi, Suzi, Yami, KTM, Gas Gas and Husky? The following table summaries their features.



	AVAILABLE TO PUBLIC	USER DEFINEABLE FUEL MAPPING	USER DEFINEABLE IGNITION MAPPING	BASIC DATA LOGGING	STAND ALONE?	FAULT DIAGNOSIS	MULTIPLE MODELS	GOOD & BAD POINTS	FACTORY TEAM RACE BIKE ECU	COST
HONDA	Yes	Yes	Yes	No Can interrogate ECU	No 12V battery required	Light in kill-switch code. SCS connector	Yes	Expensive But it does all models and years with software upgrades	Vortex	\$925 box (\$120 software upgrades)
KAWASAKI	Yes	Yes	Yes	Yes	Yes	Yes	Yes	TBA	Vortex	\$770 (\$130 software upgrades)
SUZUKI	Yes Yoshi box	Yes	Yes	No	Yes	F1 light OEM	250/450	Expensive. Different unit for old & new 450	Vortex	\$899
YAMAHA	Yes	Yes	Yes	Yes Can interrogate ECU	Yes Battery	Yes Live data	No	Heavy on batteries. Well priced.	Boyd - Stock Marmont - Vortex	\$399
KTM	Yes	Yes	Yes	Yes	No	Yes	Yes	No info yet	Stock	\$950
GAS GAS	Yes	No	No	No	No	Yes	Yes	Gas Gas maps only	N/A	\$860
HUS New tool coming for '11 MX.	No (for '08-'10, dealer only)	Yes	No	No	Yes	Yes	250/450 and BMW in '11	Apparently like the Yamaha tool	N/A. (Carby on Ando's)	TBA

THE FUTURE

EFI is here for good. Carbys will drift into obsolescence or the dual sport market at least. The two-stroke may well be the last bastion of brass until KTM releases the injected 300 disguised as a Husaberg. EFI's biggest downfall at present is dirt. It's the reason we didn't get injection for so long. The dirt bike is about as hostile as operating environments get for electronics. As plugs need to come apart for routine servicing, every unit will – no matter how well sealed – get dirt in it eventually. This is where the rot starts. Those little terminals get spread open fractionally and loose electrical content, and it's over. Tape the connectors up while the bike is new and re-tape them regularly. If a certain factory race team didn't know their air temp sensor was unplugged (they forgot to connect it), then at least taping will make you check

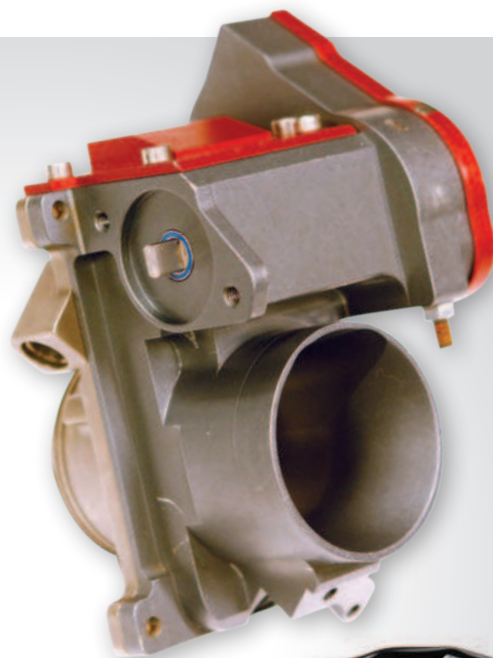
your connections.

Hopefully the future will see a throttle body with an ECU and MAP sensor integrated into it. Until then, the wiring harness will continue to be a problem.

What will these EFI bikes be like in 10 years? The sensors generally last, as do the injectors. Pumps fail, as do harnesses and plugs.

Of the aftermarket companies offering ECUs, Vortex must be doing something right. The Honda, Suzuki, Kawasaki and Yamaha factory teams all use their ECU, as do Geico and a few others in the USA.

The SSB (Simon Smart Body) is also interesting, using a slide throttle body to replace the butterfly. It's said to deliver impressive power gains, but with a reported 63hp from Cody Cooper's factory RM-Z450 this year, do we want more power? 🚀



➤ The SSB is the first slide-type throttle body built for a dirt bike. It creates unobstructed airflow at full throttle.



➤ Vortex ECUs are used by most race teams in Oz and many in the USA. They offer smaller increments for finer tuning.