Heavy Breathing

Remove the Airflow Meter and Make More Power

story and photos by david s. wallens

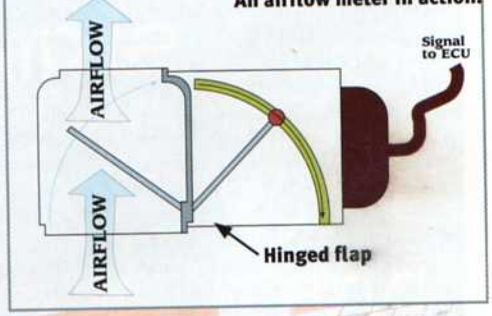
It's an old metaphor, but basically your car's engine is a giant air pump, and increasing the amount of air you get into and out of it will generally yield more horsepower. That's why most popular bolt-ons, from exhaust headers to free-flow intakes, work to minimize the obstructions the air encounters during its journey through the engine, thus helping the car produce more power.

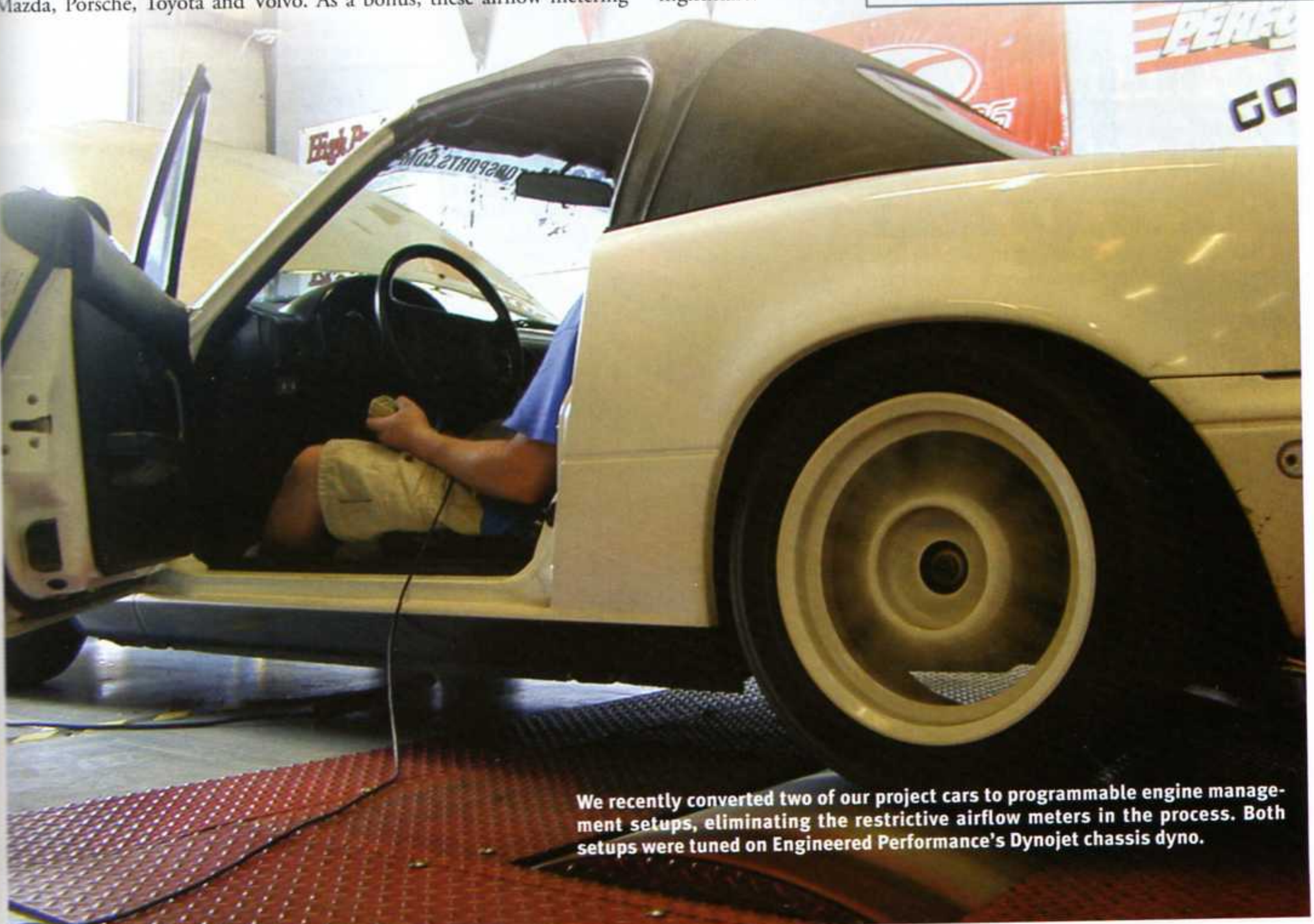
One common obstruction is the "flapper door" airflow meter. A vital part of many factory fuel injection systems built during the '70s, '80s and '90s, this airflow meter measures the amount of air entering the engine through a somewhat simple process: As the air rushes down the intake tract, it pushes against a hinged vane (flap); a potentiometer measures the amount of deflection and sends this voltage signal to the car's computer; the computer reads the signal, determines engine load and sends the necessary amount of fuel to the engine, allowing the car to run properly.

This simple, yet very effective system was used by a wide variety of car manufacturers, including Alfa Romeo, BMW, Fiat, Ford, Jaguar, Lancia, Mazda, Porsche, Toyota and Volvo. As a bonus, these airflow metering systems do not need a lot of computing power, something not entirely abundant back when they were conceived.

While it works well in stock form, the airflow meter itself is often seen as a big restriction in the air intake tract. After all, the incoming air has to push against the flap and the spring that holds it in place. Additionally, airflow meter setups tend to offer little adjustment. Adding a turbocharger, supercharger or radical camshafts to a car with an airflow meter can sometimes be a tuning nightmare.

An airflow meter in action.





We recently converted two of our project cars to programmable engine management setups, eliminating the restrictive airflow meters in the process. Both setups were tuned on Engineered Performance's Dynojet chassis dyno.

For those interested in doing away with their airflow meters, options do exist: several companies offer alternatives that convert the fuel injection setup to a less-restrictive measuring system.

To get some first-hand experience on the topic, we converted two of our project cars—our 1992 Mazda Miata and our 1988 BMW M3—from their stock airflow meter setups to alternate systems that allow more tuning while doing away with the restrictive bottleneck in the intake tract. The Miata received the Flyin' Miata/Link Programmable ECU, while the Split Second MAF Conversion Kit was installed on the BMW.

We installed and tuned the kits at Atlanta's Engineered Performance under the eyes of dyno tuner Ed Senf. Rennie Bryant, *GRM* regular and owner of Redline BMW Performance, helped with the BMW install.

The Flyin' Miata Programmable E comes complete From the top an heading clockwi the kit includes hand-held keyb manifold air pre sensor and new motherboard. W also installed a knock sensor, a available from F Miata.

Converting our Miata

As we mentioned, the Miata project received the Flyin' Miata/Link Programmable ECU. Instead of measuring the car's intake with a hinged vane, the new system uses the manifold air pressure (MAP) sensor to monitor the amount of manifold air pressure, converting that figure to a voltage signal. This signal is sent to the car's computer to determine the proper amount of fuel and ignition.

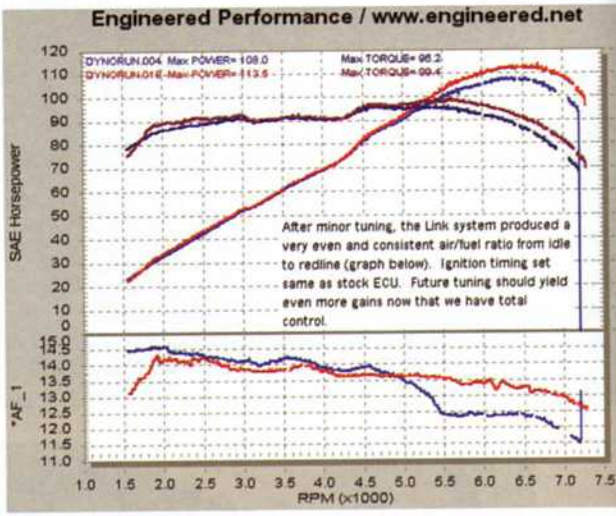
The Flyin' Miata/Link Programmable ECU is a plug in and play system, as it is designed solely for the 1990-'93 Miata and comes with everything necessary for the conversion: new ECU motherboard, MAP sensor, air intake temperature sender and programming keypad. The basic kit retails for $1,345, to which we added a Link knock sensor ($84.95 from Flyin' Miata). Besides the early Miata, Flyin' Miata offers similar programmable ECU setups for later years, too.

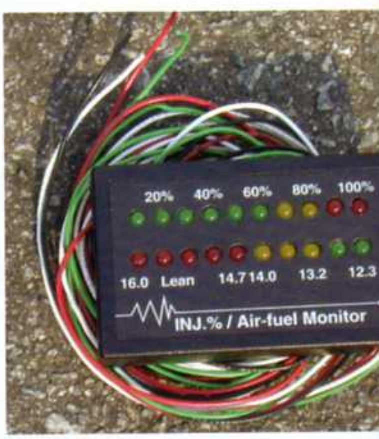
Not only does the Flyin' Miata/Link Programmable ECU remove the restrictive airflow meter, the new motherboard allows full control of fuel and timing curves. Additionally, full customization is allowed for the rev limiter, cold start and boost control, while the system is totally compatible with forced induction, radical cams and most other engine modifications.

We also added an NTK heated, four-wire oxygen sensor, available for about $80 from Engineered Performance. Where a traditional oxygen sensor only receives signal and grounds itself through the exhaust manifold or header, a four-wire setup is a little more advanced and, in theory, more accurate. Each of the four wires has a definite function, serving heat power, heat ground, signal output and signal ground.

Heating the oxygen sensor makes it more accurate at idle, while the presence of two ground wires means the unit doesn't have to ground itself through the exhaust system, manifold studs, gaskets and whatever rust/crud lies in the system.

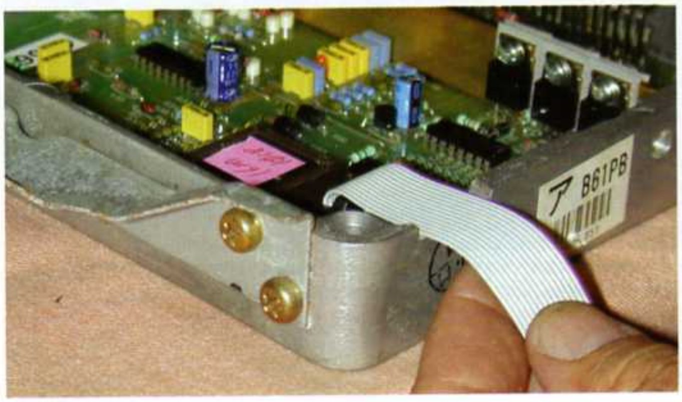
To keep an eye on both our air/fuel ratio as well as injector duty





We're using Racer Parts Wholesale's Air Fuel Monitor to measure the Miata's air/fuel ratio as well as injector duty cycle.

Below left: A ribbon cable connects the new Miata ECU to the hand-held keyboard, requiring the ECU case to be slightly notched. The keyboard can then be mounted inside the cockpit. Below right: To replace the stock airflow meter and allow us to retain our Jackson Racing Cold Air intake, a short piece of pipe was cut and installed as a spacer.



cycle, we also installed an Injector Air Fuel Ratio Monitor from Racer Parts Wholesale ($129.99). About the size of a deck of cards, the meter is easily wired into the injection system; and we used two-sided Velcro to mount ours to the interior panel just below the radio.

Our final addition was a second oxygen sensor bung, allowing Engineered Performance to mount their wide-band oxygen sensor to our Jackson Racing exhaust header. Where most standard oxygen sensors use a signal between 0 and 1 volt, the wide-band oxygen sensor goes from 0 to 5 volts, providing more resolution.

This air/fuel signal is collected by Competition Data System's Commander II module, which sends it to Engineered Performance's computer. Here it is integrated with the Dynojet chassis dyno software, providing one chart that plots both horsepower and air/fuel ratios. Besides air/fuel ratios, Engineered Performance can use the Commander II to log up to 12 parameters, including turbo or supercharger boost, exhaust gas temperature, intake temperature or oil temperature.

This extra software, plus the guy who knows how to properly use it, is one of the main reasons we trek to Atlanta for tuning. Seeing our horsepower and torque curves are great, but knowing exactly how rich or lean our engine is running during an entire dyno pull makes tuning much easier.

Before doing any baseline runs, we installed fresh NGK spark plugs gapped to .37-inch. Our air/fuel ratio dithered (centered around) at a nearly perfect 14.7:1 at idle.

We then did a few baseline runs, producing a maximum of 108 horsepower with an air/fuel curve that started a little lean before going too rich toward redline. Baseline runs in place, it was time to disassemble the stock computer and install the Flyin' Miata/Link setup.

First to go was the stock ECU motherboard, easily replaced by the Flyin' Miata/Link piece. The stock ECU case must be notched to allow passage of a ribbon cable; the remaining gap was filled with silicone sealant to prevent any wire abrasions.

Before the modified computer can be put back into the car, two wires in the ECU plug need to be swapped. It's not brain surgery, fortunately. (The Flyin' Miata instructions detail the entire process.)

Since the Flyin' Miata/Link setup eliminates the factory airflow meter, the car's intake tract must be modified to deal with the missing piece. We wanted to retain our Jackson Racing Cold Air Intake, so Engineered Performance fabricated a tubular metal spacer to replace the discarded airflow meter.

As recommended by the instructions, we used the enclosed double-sided tape to mount the new MAP sensor to the black plastic electrical cover found on the driver's side inner fender. We ran the appropriate vacuum and electrical lines and installed the knock sensor to the engine block. Since the knock sensor is basically a microphone, over-tightening its bolt can cause it to transmit the wrong signal.

We called up the appropriate program for our car—1.6-liter engine with stock injectors—and turned the key to the Start position. The car started on the first turn of the key and settled into a nice, smooth idle. We were happy campers. As per the instructions, we then set our static timing to 10 degrees BTDC.

We first used the Flyin' Miata/Link ECU's auto tune feature to get our fuel settings into the ball park. This handy feature sets fuel values as the car is driven during normal conditions; after driving for 20 to 30 minutes, you then save the values. While this could be done on public roads, we did our auto tuning with the car strapped to the dyno, allowing us to monitor the car's air/fuel mixture without having to watch for traffic.

Using the keypad, Ed further fine tuned the system, improving our car's hot start and acceleration characteristics, all the while keeping an eye on our air/fuel ratio.

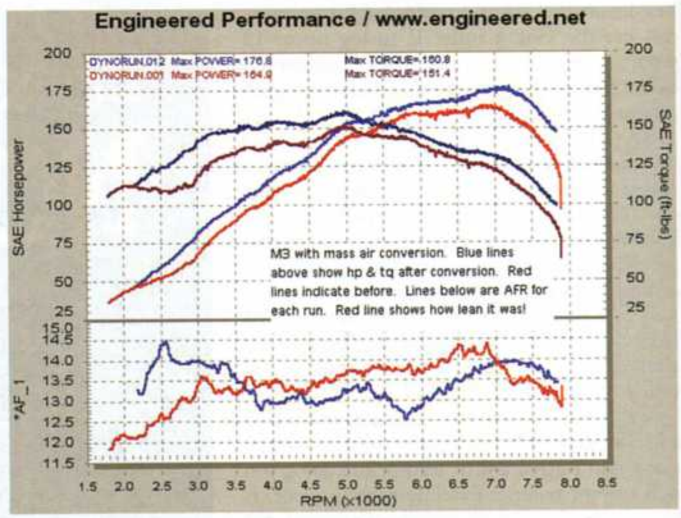
After performing the auto tune, we did a few more dyno pulls, revealing improved air/fuel ratios but a slight drop in torque and horsepower. However, advancing the ignition timing to 15 degrees BTDC quickly restored our torque and horsepower numbers to their pre-Link values.

The Split Second MAF conversion comes as a complete kit, including the actual mass airflow meter (left) and ARC2 Air/Fuel Ratio Calibrator. The 90-degree tube connects the MAF to the engine's intake plenum.

We then did a little more tuning, creating our own fuel and ignition settings. While every car will have its own settings (ours can be seen in the Project Updates section of www.grassrootsmotorsports.com), assistant tuner David Camp came up with figures that make good power yet work well for daily driving on pump gas.

With the highest total ignition advance coming at high-rpm, low-load situations, David removed 1 degree of advance per 1000 rpm from redline on down. As load increased, he removed another degree of ignition advance per load zone.

Our final dyno runs show our car once again producing a nice, broad torque curve, although there is a 5.5-horsepower gain at the top end. The air/fuel curve is now flat with a slight bend toward rich as the engine speeds approach redline; we no longer start lean and go pig rich.



The M3 Gains a MAF

Like our Miata, the 1988 M3 also came from the factory with a flapper door style airflow meter. The Split Second MAF Conversion Kit replaces that airflow meter with a mass airflow sensor (commonly known as a "MAF"), a device that uses a heated wire to determine the amount of air entering the engine. By tracking the amount of electricity needed to maintain a certain wire temperature, the car's computer can determine air flow and send the necessary amount of fuel and spark to the engine.

The Split Second MAF kit for the M3 includes the mass air flow sensor, wiring harness, air intake tube, ARM1 air/fuel ratio meter and ARC2 Air/Fuel Ratio Calibrator. Unlike our Miata setup, the Split Second MAF kit works with the stock BMW computer. Retail price is $1,000, but *GRM* readers can knock off 10 percent.

Before installing any new hardware, we hooked our BMW to Engineered Performance's chassis dyno and data acquisition equipment for a baseline run. Our air/fuel ratio looked a little lean in the middle of the run, while it was too rich by a slight amount at the top end. Despite the

Sources

Electromotive Engine Controls
(703) 331-0100
www.getfuelinjected.com
engine management systems

Engineered Performance
(770) 434-0051
www.engineered.net
dyno tuning

Flyin' Miata
(800) FLY-MX5S
www.flyinmiata.com
Miata ECU conversion

Modern Performance
(732) 222-3679
www.modernperformanceinc.com
MAF conversion

Racer Parts Wholesale
(800) 397-7815
www.racerpartswholesale.com
air/fuel monitor

Redline BMW Performance
(954) 783-7003
www.redline-racing.com
BMW tech help

Split Second
(949) 863-1359
www.splitsec.com
BMW MAF conversion

TWM Induction
(805) 967-9478
www.twminduction.com
fuel injection parts

less-than-ideal air/fuel curve, the car produced 164.9 horsepower and 151.4 lb.-ft. of torque.

As in our other installation, the first thing to do to the BMW was remove the stock airflow meter and modify the air filter housing for the new MAF. Some drilling, cutting and filing are required, but Split Second provides a template for the holes, and the job is actually quite easy. They also provide a new 90-degree, 4-inch-diameter hose to replace the original air intake tube.

With the new holes drilled, the MAF was attached to the air filter housing, and the entire intake assembly—air filter housing, MAF and 90-degree tube—was attached to the engine's intake plenum.

Next we attacked the electrical end of the conversion, splicing the Split Second ARC2 Air/Fuel Ratio Calibrator to the stock DME (Motronic control unit). The ARC2 Air/Fuel Ratio Calibrator uses four knobs—low, mid, high and accel—to calibrate the engine's air/fuel mixture.

The low knob moves the DME's output signal up or down, causing the air/fuel mixture to go rich or lean. Split Second calls this the low setting because raising or lowering the entire output signal causes greater percentage changes under low engine loads, like idle or low-speed cruising.

The linearity of the DME's signal is controlled by the mid knob, which can bow the voltage and affect mid-load values. This control can fine tune the air/fuel ratio under moderate acceleration levels.

The high knob changes the signal gain, increasing the voltage by a fixed percentage and producing a larger change at the higher end of its spectrum. Adjusting this knob adjusts the air/fuel ratio at high loads, such as those encountered during full-throttle acceleration or climbing steep grades. Throttle response is optimized by the accel knob, as it momentarily richens the air/fuel ratio.

Once it was wired in, we placed the control unit inside the car's glove box, although it could also be located on the steering column or in the center console. We figured hiding the box inside the glove box would prevent passengers from changing our settings.

Split Second's kit also includes their ARM1, a small five-color, 10-LED air/fuel ratio meter. We spliced the unit into our wiring harness and also placed it inside our car's glove box.

With fewer variables than the Flyin' Miata/Link kit, we had the Split Second kit tuned quite quickly, thanks to Engineered Performance's wide-band oxygen sensor setup. However, we did find that one click on any knob could make a huge difference in air/fuel ratios, stressing why a dyno with data-acquisition equipment is necessary for proper tuning.

In addition to a more linear air/fuel curve, we gained increases in horsepower and torque: our 164.9 horsepower climbed to 176.8, while torque rose from 151.4 lb.-ft. to 160.8 lb.-ft. While the extra top-end power is nice, the boost in mid-level torque really makes a positive difference in real-world driving conditions.

Educational Experience

Our testing has shown that removing the airflow meter and converting to an adjustable fuel-injection system makes more power, even on our relatively mild engines. When dealing with high-lift camshafts, boost or other radical modifications, having the ability to fine tune the engine's air/fuel mixture becomes even more important. GRM