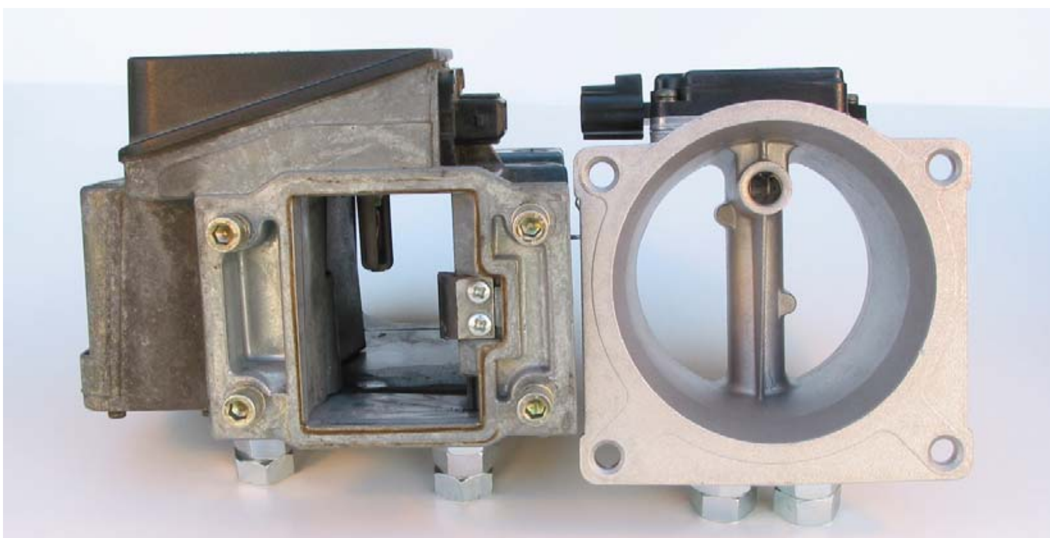
Air Flow Meter to MAF Conversion

The replacement of a stock vane-style air flow meter (AFM) with a mass air flow (MAF) sensor is one of the most effective ways to improve performance on a naturally aspirated engine. It is common to produce gains of 10 hp at the wheels on engines in the 2.5L range and higher gains on larger engines. The MAF sensor with its open cross section is capable of far better air flow than an air flow meter which results in improved efficiency and overall performance. A well tuned MAF conversion also results in improved throttle response and smoothness.

The photo below shows a Bosch air flow meter from a BMW E30 M3 on the left compared to the MAF 3.5 sensor on the right that is used to replace it in the Split Second MAF Kit. Note that the air flow meter has lots of sharp edges and protrusions that can impede air flow. The MAF sensor has a smooth opening and much larger cross section.



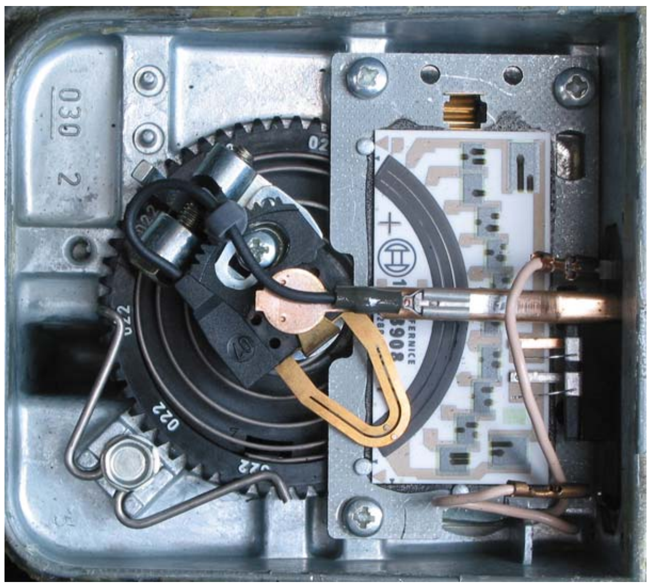
When an engine is modified by changing the air flow meter to an MAF sensor, there are a number of technical issues that must be addressed. The main challenge is to adjust the response (output voltage vs. air flow) of the MAF sensor to match the original air flow meter. Other issues include slowing down the rate of change of the MAF signal to match the response time of the slower air flow meter. Since the MAF sensor measures mass air flow, its reading is very sensitive to changes in air density. Air density changes dramatically with elevation which causes greater changes to the MAF reading than that of an air flow meter. This requires elevation compensation in the calibration circuitry. All of these technical issues are addressed in the laptop programmable PSC1-004 which is the heart of the Split Second MAF conversion system.

Since the MAF sensor samples air flow at a point in the air stream, it is also more susceptible to turbulent air flow. This requires care in the way that the MAF sensor is installed in the intake.

MAF sensors provide more stable readings when they are mounted to an air box or fed by a length of tubing that promotes laminar air flow.

Air Flow Meters

Air flow meters utilize the best technology that was available when they first came into use in the early days of electronic fuel injection. They produce a varying voltage that is proportional to air flow. Air flow pushes on a spring-loaded door inside the air flow meter. The door is pushed open further as air flow increases. The position of the door is measured by a metallic wiper moving along a resistive element. In effect the air flow meter acts like a potentiometer producing an output voltage dependent on the angular position of the door and the supply voltage. The photo below shows the view under the hood of an air flow meter.



Since air flow meters are mechanical devices, they are prone to fail over time. The contacts can oxidize, corrode or simply wear out with use. You can see a pair of grooves etched into the resistive element on this AFM which has been in use for several years. When this happens, the output voltage can completely drop out at certain load points. This inevitably leads to drivability problems. On older cars, air flow meter problems can cause flat spots, stutters, lack of power and failure to pass emission testing.

Air flow meters come in several different forms and produce a variety of output voltages. The earliest ones were designed to operate directly from the +12 V battery voltage on the car and produce an output over the range of 0 to 9 V. Later units were designed to operate from a regulated 5 V reference provided by the Electronic Control Unit (ECU) and produce a 0-5 V output. There are other variants that produce a 5 to 0 V output where the voltage decreases as the flow increases.

Split Second offers different calibrators for each of these types of air flow meters. The PSC1-004 is used for 0-5 V systems. The PSC1-005 is used on 5-0 V (inverted) systems and the PSC1-009 is for 0-9 V systems.

Here is a procedure that you can follow to determine which type of air flow meter you have.

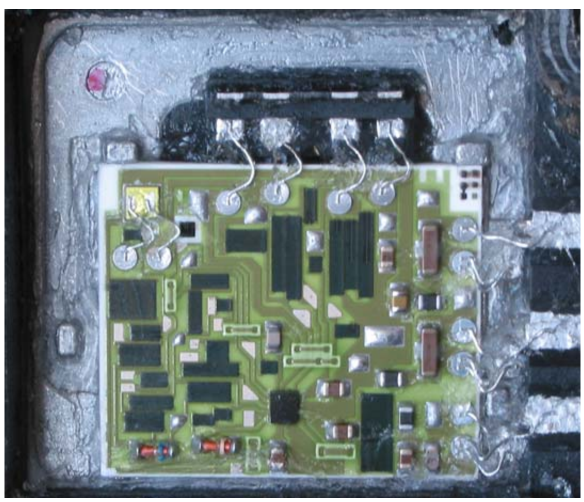
1) Remove the air box or intake so you can push open the air flow meter door by hand.
2) Use a DVM set to DC volts with the negative probe connected to chassis ground.
3) Measure the voltage on each wire with the ignition-on and engine-off.
4) As you measure each wire move the door open and closed by hand.
5) Only one wire will have a voltage that changes as the door is moved. That is the signal wire.
6) Once you identify the signal wire, note the voltages with the door fully closed and fully open.

MAF Sensors

In contrast to air flow meters, MAF sensors utilize solid state circuitry and a sophisticated technique to measure the mass of air flow into the engine. This technique is based on a heated wire or film. The heated element is cooled by air flow. The amount of current required to overcome the cooling and maintain a constant temperature is directly proportional to mass air flow. The circuitry inside the MAF sensor turns this current into a precisely calibrated voltage reading.

The amount of fuel required by the engine is directly related to mass air flow. The direct measurement of mass air flow provides an effective way to control fuel injection over changes such as temperature, air density, elevation change and aging of engine components.

The photo below shows the circuitry inside an MAF sensor. It utilizes surface mount and custom integrated circuit technology to produce a very accurate and reliable air flow measurement.



There are a few things to be careful of when using MAF sensors. Avoid dropping the sensor or exposing it to shock. Avoid excessive oil on rechargeable air filters. The oil can coat and degrade the sensor element. CRC MAF sensor cleaner can be used to clean the element. Avoid generic electrical cleaners.

MAF sensors operate from the +12 V battery voltage. They have internal regulation that insures that the measurement is accurate as battery voltage changes. Most MAF sensors used in automotive applications have an output signal range of 0-5 V, 0-5 mA or 0-10 kHz. The sensors used in Split Second MAF kits produce a nominal 0-5 V output signal.

Installation Tips

The sensors used in Split Second MAF kits use a sampling tube. This allows the sensing element which is exposed to a small portion of the cross section to measure total air flow. This works as long as the air flow is smooth. If the air flow is turbulent, the flow measurement will be inconsistent. This can lead to serious drivability problems. For this reason, MAF sensors work best when mounted to an air box or fed by a minimum of 9 inches of tubing. This assures smooth air flow through the sensor. It is best to avoid mounting a cone filter right at the inlet to the MAF sensor.

The photos below compare the stock AFM installed on an E30 M3 on the left with the MAF 4.0 sensor installed on the right.

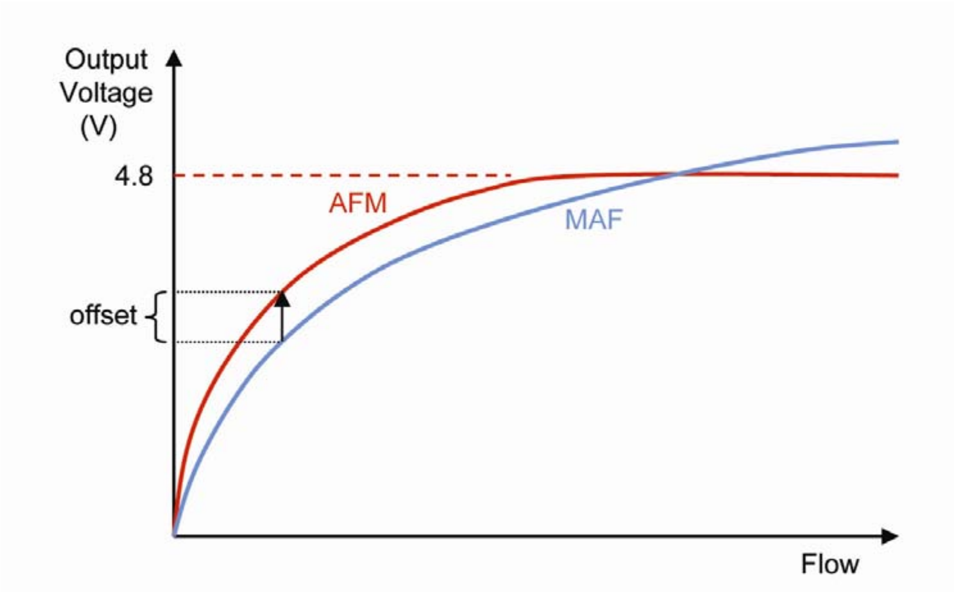
In addition to the larger diameter of the MAF sensor you can see the much larger diameter of the elbow connecting the MAF sensor outlet to the plenum. While you are opening up the cross section at the MAF sensor you should also look at other places to make improvements. Many manufacturers put a small diameter tube on the inlet to the air box. This is done to minimize intake noise. This tube can be replaced with a larger diameter tube to open up the inlet to the air box.

Always install the calibration electronics in a location that is relatively cool and dry. Popular locations are behind the dashboard or in the glove box. The ground wire for the calibrator should be connected to the ground for the air flow meter. Make sure that the +12 V source used to power the calibrator holds at full voltage during cranking. Many accessory circuits drop out during cranking to provide maximum current to the starter motor. If the power to the calibrator falls off during cranking, the engine will be hard to start.

Most air flow meters have a built in air temperature sensor. Split Second calibrators have a grey wire that can be used to provide a fixed air temperature reading. Cold start and run during warm-up can be improved by running a dedicated air temperature sensor. The Split Second IAT1 is available for this purpose.

Match the Output Signals

A simplified comparison of AFM and MAF signals is shown below.



The AFM signal shown in red rises rapidly as flow increases from zero. This makes the AFM very sensitive to small changes in flow at light load. As air flow increases, it pushes harder against the spring-loaded door and opens it wider. When the air flow is high enough, the door is pushed all the way open and the signal tops out at its maximum value. That maximum value is at 4.8 V in the example above.

The MAF sensor signal shown in blue has less curvature than the AFM signal. As air flow increases the output voltage increases at a lower rate compared to the AFM. Even though MAF sensors may be specified with a 0-5 V output they are capable of generating voltages higher than 5 V with sufficient air flow.

Adjusting the MAF signal to look like the AFM signal involves applying a series of offsets to the MAF reading. The magnitude of the offset is represented as the height of the arrow shown on the graph above. In a calibrator like the PSC1-004, the offset is applied according to cell values in a map table. The voltage from the MAF sensor is broken up into 50 segments in the table. This provides the resolution needed to fine tune the fuel curve over the entire load range of the engine.

At zero flow, both sensors output zero volts. No offset is required to match the signals at zero. As the flow increases, an increasing offset must be added to the MAF sensor signal to match the AFM signal. At the mid-load area, the offset reaches a maximum. The offset decreases beyond that point. When the MAF sensor signal reaches the AFM signal at its 4.8 V maximum, the offset value returns to zero. Above 4.8 V an offset is subtracted from the MAF signal to hold it to a maximum of 4.8V. The calibrated signal must be restricted to the voltage range of the stock AFM.

Closed Loop vs. Open Loop Operation

All engines that have an O2 sensor are able to operate in closed loop mode. In this mode the ECU fine-tunes the fuel mixture as you drive. Most vehicles that have an air flow meter have a narrowband O2 sensor. The narrowband O2 sensor is highly accurate at 14.7:1 which is known as the stoichiometric air fuel ratio (AFR). This AFR is targeted for the best compromise between fuel economy, performance and emissions. Stoichiometric AFR is essential to the proper operation of catalytic converters.

In closed loop mode, the ECU uses the reading from the O2 sensor to measure the fuel mixture. This information is used to adjust the injector pulse-width to maintain stoichiometric AFR. This AFR is targeted during idle, cruise and moderate acceleration. The base fuel, or nominal injector pulse-width is set according to air flow, RPM and environmental factors. The base fuel is modified according to O2 sensor feedback through a process called adaptation. Adaptation occurs both in real time and based on history. Historical adaptation data is stored in volatile memory that can be cleared by disconnecting the battery on the vehicle for 10 minutes.

A large part of the tuning process involves achieving stoichiometric operation over the light-load range. This is the range where we spend most of the time in during daily driving. Tuning this region is essential to achieving good drivability.

ECUs that use narrowband O2 sensors need to be able to switch off the closed loop process to achieve enrichment. When the closed loop mode is switched of, the engine is operating in open loop. In open loop, the ECU no longer uses the O2 sensor to fine-tune the fuel mixture. Under high load conditions, the engine computer targets a richer mixture than 14.7:1 to safely support the combustion process. An AFR of 12.5:1 is typical for high load conditions.

Engine Tuning Tools

The single most important tuning tool is the wideband lambda meter. Particularly when mounted in a bung located in the pre-cat location, the wideband lambda meter will provide a highly accurate measurement of air fuel ratio. If is it not possible to locate the sensor in the pre-cat location, you can used a tailpipe clamp. The tailpipe method will usually match the pre-cat location reading within a variance of 0.3 AFR.

Split Second MAF kits come with the ARM1 air fuel ratio meter. It operates from the stock narrowband sensor. The main purpose of the ARM1 is to monitor the fuel mixture during daily driving. Once you become used to how it reads, the ARM1 can be an effective warning that the tune has changed. The ARM1 can also be an effective tuning tool.

Narrowband oxygen sensors are highly accurate near the stoichiometric point. The entire closed loop region of operation is tuned for stoichiometric operation. That means that the ARM1 can be used for most of the tuning that needs to be done. The ARM1 can also be used to tune for the richer mixtures required at high loads. The tuner has to be aware that the ARM1 will provide an approximation to the actual air fuel ratio when the AFR is significantly richer or leaner than 14.7:1. If the ARM1 is used to tune the high load region, it is a good idea to verify the tune for the correct air fuel ratio with a wideband meter.

If the vehicle that is being tuned has a diagnostic port, it is a good idea to use a diagnostic tool for tuning the closed loop region. Diagnostic ports became common around the 1988 model year. These ports are usually found under the hood and are either circular or rectangular and covered by a protective cap. The on-board diagnostics used in the 1998 to 1995 model year range are referred to as OBDI. On-board diagnostics were manufacturer specific up until the 1996 model year when the universally standardized OBDII standard came into use.

In order to use the OBDI diagnostic port you will need to use a manufacturer specific diagnostic tool. Many of these tools are made by manufacturers that serve the automotive aftermarket. These tools are commonly used by independent shops that do service and repairs. Most scan tools will show adaptation as a multiplier. A value of 1.00 is neutral. Numbers greater than 1.00 indicate that the ECU is adding fuel (increasing injector pulse width). Numbers less than 1.00 indicate that the ECU is subtracting fuel.

Tuning Basics

Once the MAF conversion is installed we can turn our attention to tuning. Even if a chassis dyno is available, it is best to get the tune as close as possible on the street before dyno tuning. If a base map is available for the application, it is best to start there. If no base map is available, you will have to start from scratch. Before you start the tuning process, clear any adaptation that may be stored in the ECU. Remove the power to the ECU by either disconnecting the battery or unplugging the ECU for 10 minutes.

If a scan tool is available for the vehicle, it will provide the best information for tuning the closed loop region. Tune the engine for neutral adaptation with the O2 sensor connected. If a scan tool is not available the closed loop region will have to be tuned according to AFR. If you tune according to AFR you will have to unplug the stock O2 sensor before tuning. Either way you will be tuning the idle, cruise and moderate acceleration load ranges for 14.7:1 air fuel ratio.

The PSC1 family calibrators use the R4 engine management software. Be sure to familiarize yourself with the software before using it. A data sheet and app note are available that provide a good introduction to the software. While tuning it is a good idea to save the calibration file periodically so you have a way of going back to a previous tune. The R4 software has no save-as function. Save the file by closing it. The file will automatically save in its current state. Continue tuning by creating a new file and doing a read-data-from-ECU to put the current calibration into the new file. You can use the notes section on the R4 main screen to make notes about the conditions for a specific tune. For example, if you have an adjustable fuel pressure regulator, it is a good idea to note the fuel pressure used with that file.

The process of tuning the fuel curve is one of coming up with a series of calibration values that will provide the desired fuel. In the R4 program these calibration values are known as cell values. These cell values are organized on a table that resembles an Excel spreadsheet. Columns represent the MAF voltage. The voltage increment between columns is 0.1 V so there are 50 columns covering the 0-5 V range. Rows represent RPM. The RPM increment between rows is 500 RPM so there are 16 rows to represent the 0-8,000 RPM range.

Since the main thing we are tuning is voltage vs. flow, it is best to disregard RPM at the beginning of the tuning process. We do this by using the same cell value for all cells in a given column. This simplifies the tuning process from finding 800 cell values down to finding 50 column values. After the column values are as close as you can make them, you can do some fine tuning by changing individual cells within a column. The only places in the table where that may be necessary are in the idle region and at wide open throttle (WOT).

The R4 software does not allow tuning in real time. The procedure for tuning is to evaluate how the engine is running, make changes to the map table, turn off the engine, write the calibration file, restart the engine and reevaluate how the engine is running.

Street Tuning

Once you have a map that is close enough to get the engine to start, you can begin tuning. Make sure the engine is completely warmed up. Adjust the columns in the idle region which is usually between 0.8 and 1.2 V for 14.7:1 AFR. After the idle is set, free rev the engine to move over a few columns in the map table. Adjust the columns just above idle for 14.7:1 AFR.

Once you get the car to start, idle and free rev, you are ready for some street tuning. It is best to do this with two people. Have one person drive the car. The driver can vary the throttle to move the active cell (shown as a blue highlight) into the desired column. The other person can watch the fuel mixture and make map table changes. Be careful to avoid running the engine lean under load. Work your way up in load gradually. If you set one column for 14.7:1 and another column that is five columns over to 14.7:1, you can fill in the intermediate columns using the autofill function.

Since you must have the key-on and engine off in order to write a file, the easy way to tune is to check the tune at several different load points and make changes to several columns before writing a revised file. With a little bit of experience you will be able to predict how much you need to adjust the cell values to get the desired change in AFR. Tuning will be a process of driving the car at various throttle positions and adjusting several different columns in the table.

Conduct you street tuning session on an open road with no traffic around. Get the vehicle into a light load cruise condition like third gear and a 30 mph constant speed. The blue highlight will be in the light load region somewhere around 1.5 V. Evaluate the tune. If you are tuning by AFR and you are getting a lean reading of 16.0:1 for example, you need to increase the cell values in that region of the table to make the mixture richer. Since tuning does not occur in real time, the AFR will not change yet. Move up the table by a few columns say to 1.8 V by having the driver apply a little bit of throttle. Evaluate the tune at that load and make appropriate changes. Continue moving up on the table and making changes. When you get to about half throttle, pull the car off the road to a safe location and write the revised file. Repeat the process until you have the entire load range up to ½ throttle set to 14.7:1 AFR.

The entire load range up to roughly 2/3 throttle is set to 14.7:1. The higher load region is tuned for a richer mixture in the 12.5:1 range. The point where enrichment begins can be determined by watching the fuel enrichment number on the scan tool or by monitoring the voltage coming from the WOT switch on the throttle position sensor.

Complete the tune by adjusting the entire open loop region for the target rich AFR. Note that you need to keep the calibrated MAF sensor signal within the signal range of the stock AFM. This is typically around 4.8 V. The fuel mixture will go lean if you exceed that voltage.

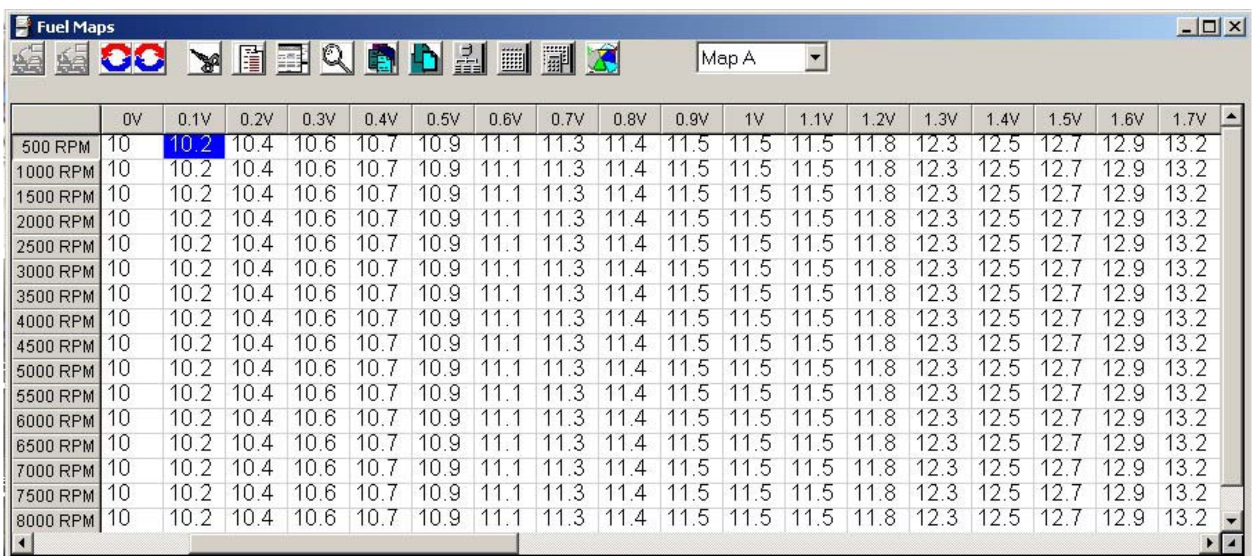
As part of your street tuning process, pay attention to how the engine starts and idles. If the engine surges at idle, you may have to make the cell values a little higher in the idle region. Another cause of surging is too much change in cell values between columns in the idle region. By using the same cell value over several columns in the idle region, you can stabilize the idle.

As you get closer to the optimum tune in the part-throttle region, you will feel the engine become more smooth and responsive. This is the part of street tuning that will affect how the vehicle feels in everyday driving. Pay close attention to flat spots that you feel as the vehicle accelerates. Note the AFR and location in the map table to identify place where you can fine tune the map for consistent AFR and smooth acceleration.

If you tune the engine in open loop with the O2 sensor disconnected, be sure to plug in the O2 sensor when you are done. Spend some time driving around with the sensor connected. Allow the ECU to adapt to the O2 sensor readings. Make sure that the engine settles into a stable state of tune. If you have the ARM1 connected, you should observe a smooth dither pattern. The display should sweep back and forth spending an equal amount of time high and low. The dither pattern should remain smooth and go back and forth faster and faster as throttle position increases from a light load cruise to the point of enrichment at 2/3 throttle. The tune isn't right if at some point during acceleration the display favors one side or sticks rich or lean.

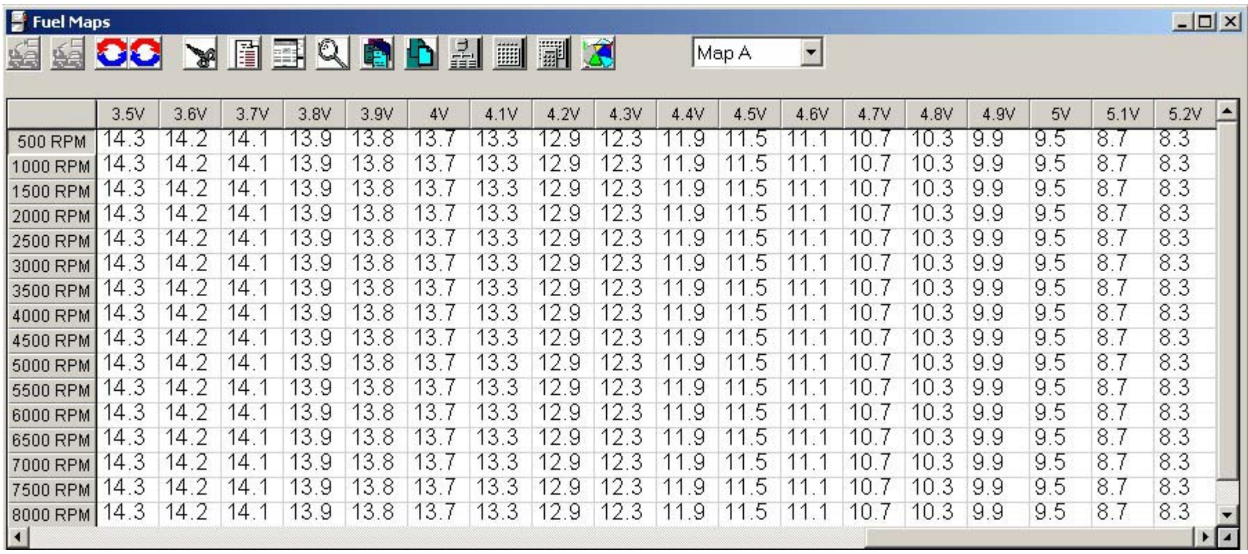
The screen shots below show an R4 fuel map from an actual calibration file used for MAF conversion. Note that the cell values are the same throughout entire columns. The neutral value in the table is 10.0. A value of 11.0 adds 0.25 V to the signal. A value of 14.0 adds one volt to the signal. The mathematical expression for the offset is:

$$Vos = (CV - 10)/4$$



	0V	0.1V	0.2V	0.3V	0.4V	0.5V	0.6V	0.7V	0.8V	0.9V	1V	1.1V	1.2V	1.3V	1.4V	1.5V	1.6V	1.7V
500 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
1000 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
1500 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
2000 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
2500 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
3000 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
3500 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
4000 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
4500 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
5000 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
5500 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
6000 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
6500 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
7000 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
7500 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2
8000 RPM	10	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.4	11.5	11.5	11.5	11.8	12.3	12.5	12.7	12.9	13.2

This image shows the light load end of the load range. Note that the cell values start out at 10.0 in the 0 V column. This assures that with zero volts in you get zero volts out. As the voltage increases, the cell values increase to produce the curvature needed to produce the required signal. The cell values have a plateau at 11.5 in the 0.9, 1.0 and 1.1 V columns. This produces a stable idle. The cell value of 11.5 adds 0.375 V to the reading.


Fuel Maps

Map A

	3.5V	3.6V	3.7V	3.8V	3.9V	4V	4.1V	4.2V	4.3V	4.4V	4.5V	4.6V	4.7V	4.8V	4.9V	5V	5.1V	5.2V
500 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
1000 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
1500 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
2000 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
2500 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
3000 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
3500 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
4000 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
4500 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
5000 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
5500 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
6000 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
6500 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
7000 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
7500 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3
8000 RPM	14.3	14.2	14.1	13.9	13.8	13.7	13.3	12.9	12.3	11.9	11.5	11.1	10.7	10.3	9.9	9.5	8.7	8.3

This image shows the high load end of the map table. The cell values peak at 14.3 which adds 1.075 V to the reading. At the 3.6 V column the cell values start to trend downward. Note that there is a decreasing sequence of cell values above 4 V. This is done to maintain the reading within its nominal range. The cell value drops by 0.4 per column which corresponds to 0.1 V. Therefore for each increase of 0.1 V at the input, the PSC1 will subtract 0.1V at the output. This holds the output to just below 5 V which keeps the engine from leaning out at high RPM.

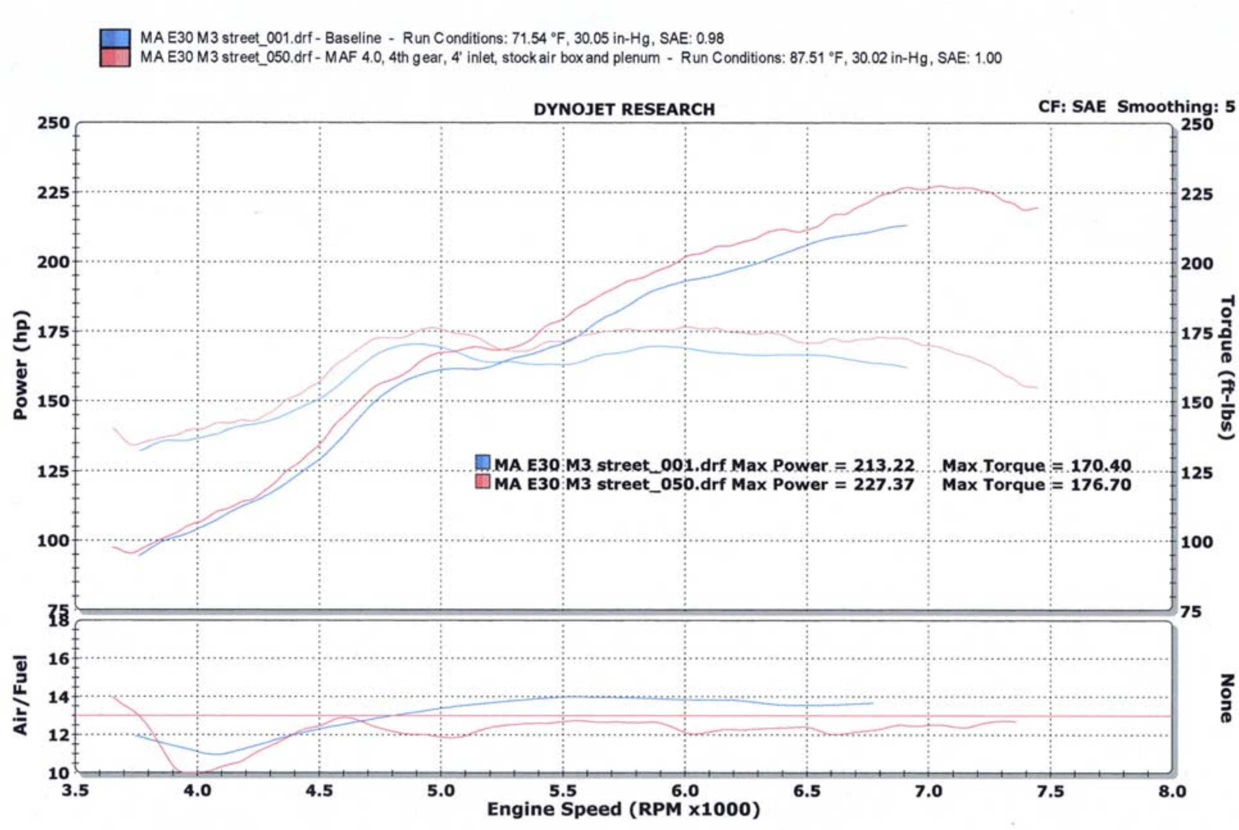
Dyno Tuning

Only dyno tune the engine after you have done a complete street tune. Use the dyno to flatten out the fuel curve over the RPM range at WOT. Use the data recording feature to correlate what is happening in the R4 program with the results on the dyno. Click start record at the beginning of the dyno pull and stop record at the end. All recordings are saved in the R4 file by time and date. You can use RPM to relate the location in the map table with the measured AFR on the dyno. This will direct you to where you need to make changes to the map table.

During a dyno pull, it is common for the trace to stay within a narrow range of columns at high RPM increases. This makes it necessary to change cell values by row in the high load region of the table rather than by column as we do in the rest of the table.

The dyno graph below is for a 2.5L BMW E30 M3 with 284/276 cams and optimized exhaust. The chart shows the difference in running a stock AFM compared to the MAF 4.0 sensor. The MAF conversion picked up 14 horsepower. More importantly it shifted the horsepower and torque curves up over the entire RPM range.

Note that the baseline run in blue is lean with the AFR near 14.0:1 for most of the run. In addition to making more horsepower and torque, the run with the MAF conversion shown in red is much richer and close to the 12.5:1 target AFR.



An MAF conversion is a great way to modernize an older engine management system. It can make a significant initial improvement in horsepower and torque. Along with that you generally see improvements in smoothness and throttle response. It also provides a way to fine tune the engine to account for other engine modifications.