Late Model GM Ecu Tuning

Contents

Lambda vs AFR – What does it all mean?

Since pump gas is the most common fuel, most wideband meters are calibrated for the stoichiometric ratio of (14.7:1). The important part to understand is that the wideband meter doesn't know (or care) what fuel it is reading. All it is looking at is the oxygen content in the exhaust. The wideband meter basically works natively in lambda and in order to display AFR, it must be told what air fuel ratio equates to lambda 1.00 so it can display the right number.

So lets assume that the wideband meter is set for a stoichiometric AFR of 14.7:1. This means when it is reading lambda 1.00 (regardless of fuel), it will display 14.7:1. Run it at lambda 1.00 on VP 109 and it will read 14.7:1. Run it at lambda 1.00 on E85 and it will read 14.7:1. Run it at lambda 1.00 on methanol and it will read…. you guessed it, 14.7:1.

Right, now let's assume we are running at 0.85 lambda. Our wideband is still configured with a stoichiometric AFR of 14.7:1. 0.85 x 14.7 is 12.495:1. This means that regardless of the fuel type, the wideband will read 12.495 if we are running 0.85 lambda.

If however we adjust the stoichiometric setting in the wideband for the fuel we are running, everything changes. Let's say we change to VP 109 and we set the wideband to a stoich ratio of 13.4:1. Now when the lambda is 1.00, the wideband will read 13.4:1. If we run 0.85, the wideband will read 0.85 x 13.4 = 11.39:1.

In Short, As long as your wideband is setup for petrol/gas @ 14.7 then setup the car's ecu to match the same figure or vice-versa. This then makes the "BEN Factor" more accurate when it comes to tuning.

Lambda 1.00 is stoichiometric, regardless which fuel you use. 14.7:1 for pump gas, 13.4:1 for VP 109, 9.8:1 for E85.

Some GM ecu's will work in either AFR/Lambda or EQ, EQ is essentially the opposite number for richening mixtures to that of Lambda, but 1 is ALWAYS Stoich.

Oxygen Sensors – Wideband vs Narrowband

A wideband is a high precision oxygen sensor, with there being 3 common Wideband Sensors on the market. They are the Bosch 4.2, 4.9 LSU and NTK/Uego sensors. Most wideband kits utilize Bosch sensors due to costs, the 4.9 is a much faster reacting sensor and thus with the right controller can provide more samples per second. Being of a newer design the 4.9 is also less prone to contamination of the "clean air" sample like in the 4.2 and heat resistant.

Both sensors recommend to be "free air calibrated" often depending on use. If you think your sensor data is bad always check against another for peace of mind. It doesn't hurt to check.

http://www.ecotrons.com/technology/bosch_lsu_49_is_superior_to_lsu_42_sensors/

NTK/Uego sensors are even older than the bosch 4.2 sensors and thus are not as accurate/quick in sampling the air stream. http://wbo2.com/lsu/sensors.htm

There are a few other older "wideband" sensors on the market but I would not recommend using these for any critical engine tuning.

Most GM ECU systems utilise narrowband sensors to provide minor corrections to fuelling, this is because as there name suggests they have a NARROW margin in which they can sense either a rich or lean mixture. It's not recommended to tune off these alone, but it can be done, just not to any great precision.

Sensor Location

Most wideband controllers will mention a minimum distance from a collector merge or distance from a turbocharger. This is mostly due to the sensors safe operating zone, too close to the engine and exhaust pulses and heat will affect the sensors life span. Angle of the sensors is mainly to prevent fuel/water vapor from building up around the sensor tip.

Analog vs Digital

Most good widebands on the market now offer serial (rs232) or CAN based output along with an analog 0-5v signal.

When tuning it is **preferred** to utilize the digital form of data from the wideband into your tuning software, so that the data the wideband is transmitting is exactly what you see in the logger. With analog signals you can get ground offsets based on where your powering your wideband, even noise from the widebands own electronics when producing the 0-5v output from the original digital signal, even the alternator load can affect the readings you get from the wideband.

Nothing is more frustrating than watching a gauge and seeing perfect fuelling and then finding your logger has recorded something completely different.

MAF & Virtual VE / Speed Density Tuning - EFILIVE

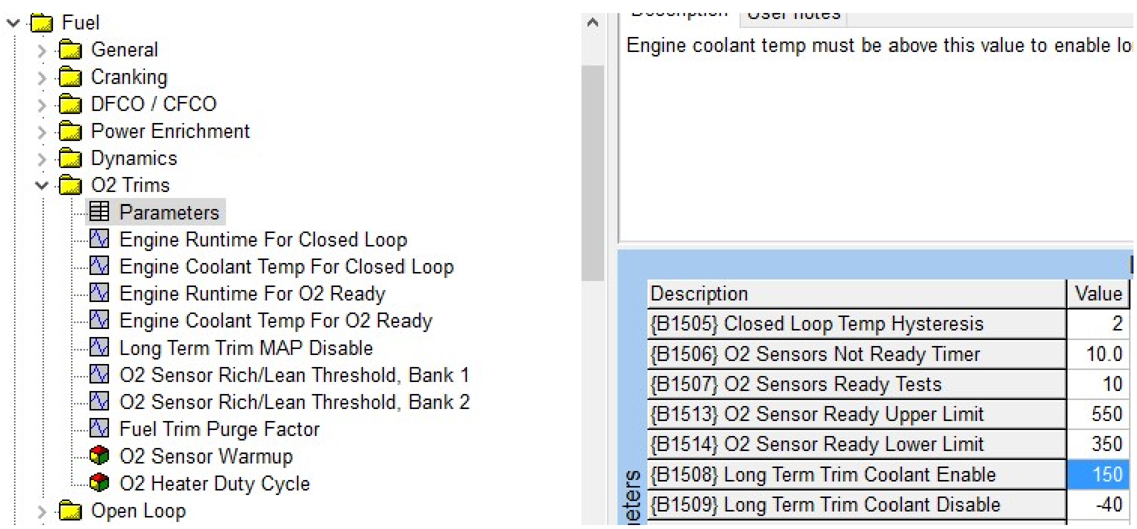
Open Loop vs Closed Loop

All tuning should be done in Open loop otherwise you will be fighting against the ecu itself, which will be trying to correct the mixtures the car is running i.e the ecu will be trying to get fuelling back to stoich.

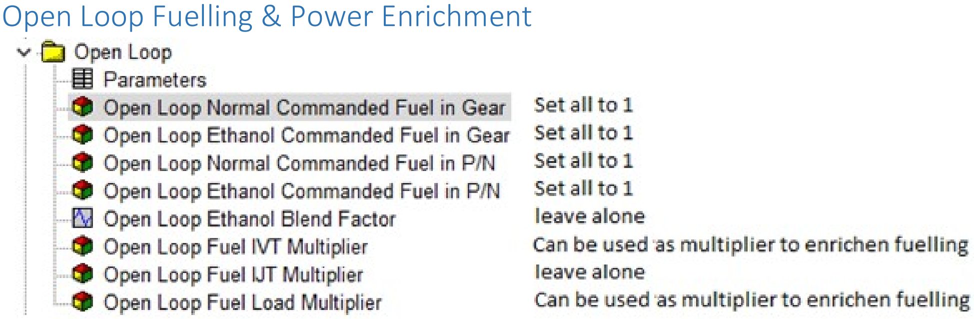
To force an ecu into running open loop, you simply set the following tables in Efilive/HPT to 140c (basically a value the car will never get to under normal operating conditions)

1) Engine Coolant Temp for Closed loop
2) Engine Coolant Temp for 02 Ready

Additional to setting the above, it's recommended to turn off long term trim adjustment. In Efilive you can find all these values in the "02-Trims" Parameter section under "Fuel"



Open Loop Fuelling & Power Enrichment



MAF (Mass Air Flow) vs Mafless (Speed Density)

Factory GM ecu's all run a combined speed density/Maf tune and will default to the MAF airflow figures from a "High Speed" rpm switch point.

Description	Value
{B8024} High Speed Mode RPM Enter	8000
{B8025} High Speed Mode RPM Exit	8000

The above image is the switch point set on a MAFless speed density tune. It's set to a range outside of the normal operating range for good measure (though typically once the car has failed on the maf, it makes no difference what the value is). A typical rpm for a stock GM calibration is often 4000rpm with an exit at 3900.

So if rpm is over 4000, the airflow calculations will be based purely on what the maf is seeing, once it gets below 3900 it will blend the maf data with the speed density data. Generally maf airflow will stay pretty consistent during cam changes and fuelling will not be greatly affected. However a speed density based tune is greatly affected by the underlying fuel map and is often not calibrated on OE tunes to such fine degree we can achieve.

Operating RPM & MAP Zones

Efilive provide a good explanation on how the Rpm & Map zones work by default, but you can tailor the zones to work for you, especially with camshaft or supercharged vehicles for zones better suited to manifold vacuum at cruise and boost pressure.

Essentially the zones allow you to target specific areas of your fuel map more precisely. Just bear in mind that the mathematics behind the virtual fuel map won't allow large changes/swings within a zone.

Virtual Volumetric Efficiency

See Simon Wingtans Tutorial

Tuning via BENs is the way to go. Demonstrate creating VVE Map, What's required for getting fuel map where we want it.

Importance of Open Loop & PE tables, how they work and affect enrichment. What happens when put it into closed loop.

Predicted Charge Temp Coolant Modified, how we can use it for our benefit.

What gets broken by going into SD, i.e dynamics etc.

MAF Tuning

MAF tuning is simple, it's a 1 dimensional map. Demonstrate how to create a map for MAF BEN. Closed Loop MAF, Open Loop MAF. Higher numbers = more fuel, lower is less

Idle Airflow Tuning

It's all in the airflow. Tables of importance = B1650-52, Minimum idle airflow tables & corrections. Importance of Idle spark effect/correction on idle steadiness. Pro's & con's of drilling the throttle blade.

Timing Tuning

Idle

Stock cam, not really required. Bigger cams will generally want to start around 15 degrees as the base, then allow idle spark control to find the happy medium. If spark is consistently being added then bump base. Same if it's idling too high. Main Spark map must always be higher then the idle maps. Think of main spark maps as the ceiling to what the base map + adders can go to.

Part Throttle

Main spark map, without live tuning this can be an extremely exhausting task to perform. However generally on the dyno your looking for the most torque the engine creates at a given load/map with the least amount of timing. No point having 45 degrees of timing if the engine creates the same torque at 36.

Generally the factory maps are good for stock motors using fuel they were originally tuned for, but when it comes to camshaft/supercharged engines using the stock map and then using bidi controls to remove timing will help to dial in your timing, unfortunately with no live tuning this will always be a time consuming process. As you will need to record the timing, Generally when the engine create the most torque it for cruising/light load it will generally have the highest amount of vacuum.

Weight of the vehicle will affect the amount of timing the car will take on the road. Not so much on the dyno unless using an eddy current load dyno. Inertia dyno's cannot load the car where required.

Wide Open Throttle

Just like part throttle we want the least amount of timing required to create the most hp. Aka MBT (mean best timing or minimum best timing) without creating or producing knock from the engine. With boosted motors, if we are starting out from an existing tuned car we would add the required 2 bar map sensor/injectors etc and if the injector data is correct we should be safe to assume that wherever the max G\Cyl was achieved when NA. we should start to remove 1-1.5 degrees as a baseline per .04 g\cyl towards the higher g\cyl.

For example at sea level or close to 100kpa barometric pressure we should achieve between .76 to .84 g\cyl at full throttle when naturally aspirated. As such from .84 onwards we would start to remove 1.5 degrees of timing to prevent knock/detonation for .88 to 1.04g\cyl etc. How far we go will depend on the amount of boost the engine is going to run, along with the quality of fuel used.

	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.16	1.20	1.24	1.28	1.32	1.36
1400	21.0	17.5	15.5	13.5	11.5	10.0	9.5	8.5	7.5	6.5	5.5	4.0	2.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1600	23.5	20.5	18.5	16.0	14.5	13.0	12.0	11.5	10.0	9.0	8.0	6.5	5.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
1800	26.5	23.5	21.5	18.5	17.0	15.5	15.0	14.0	13.0	12.0	10.5	9.0	7.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
2000	30.0	27.0	24.5	21.5	20.0	18.5	18.0	17.0	16.0	15.0	13.0	11.5	10.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
2200	31.5	28.5	26.5	24.0	22.0	20.0	19.5	18.5	17.5	16.5	14.5	13.0	11.5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2400	33.5	31.0	28.5	26.0	23.5	21.5	21.0	20.0	19.0	18.0	16.0	14.5	13.0	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
2600	34.0	32.5	30.0	27.0	25.0	23.0	22.0	20.5	19.5	18.5	17.0	15.5	14.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
2800	35.0	33.5	31.5	29.0	27.0	24.5	23.0	21.5	20.5	19.5	18.0	16.5	15.0	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
3000	35.0	33.5	31.0	28.5	27.0	24.5	22.5	21.5	21.0	20.0	18.5	17.0	15.5	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
3200	34.5	33.5	30.5	28.0	26.5	24.5	22.5	22.0	21.5	20.5	19.0	17.5	16.0	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
3400	34.0	32.0	29.5	27.5	26.0	24.0	22.5	21.0	20.5	19.5	18.0	16.5	15.0	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
3600	33.0	30.5	28.5	26.5	25.0	23.5	22.0	20.0	19.5	18.5	17.0	15.5	14.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
3800	32.0	29.5	28.0	26.0	24.5	23.0	21.5	19.5	19.0	18.0	16.5	15.0	13.5	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
4000	31.5	28.5	27.0	25.5	24.0	22.5	21.0	19.5	18.0	17.5	16.5	15.0	13.5	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
4200	29.0	27.0	25.5	24.0	23.0	21.5	20.0	19.0	18.0	17.0	16.0	14.5	13.0	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
4400	27.0	25.5	24.0	22.5	21.5	21.0	19.5	18.0	16.5	16.5	15.5	14.0	12.5	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
4800	26.0	24.5	23.0	21.5	20.5	20.0	19.5	19.0	18.0	17.5	17.0	15.5	14.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
5200	25.1	23.6	22.1	20.6	20.3	19.8	19.4	19.1	18.0	17.5	17.0	15.5	14.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
5600	24.2	22.7	21.2	19.7	20.0	19.7	19.3	19.2	18.0	17.5	17.0	15.5	14.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
6000	23.8	22.3	20.8	19.3	20.5	20.3	20.2	20.3	19.5	19.0	18.5	17.0	15.5	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
6400	23.5	22.9	22.3	21.6	21.0	21.0	21.0	21.5	21.0	20.5	20.0	18.5	17.0	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
6800	23.5	22.9	22.3	21.6	21.0	21.0	21.0	21.5	21.0	20.5	20.0	18.5	17.0	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5

Once you have a few tunes under your belt, you will get a better understanding of what sort of baseline spark maps you can use.

Before performing any full WOT runs it's best to do a quick load test or short power run at low throttle/pedal movement keeping say 100-120kpa to make sure that all fuel and timing is where we expect it, with boosted motors it's possible to be in boost at lower pedal positions.

Injector Data is Critical

How does the IFR table affect fuelling and thus spark maps.

Injection Timing Events on fuelling

B1205 & B1206 effect on fuel smell etc with large camshafts

VE Compensations

Seems to only effect Blended tunes, i.e MAF where they transition to high speed.

Torque Model Co-efficient for Automatic transmissions

Not so critical on manual cars, Touch on this if required for GM automatics