ACCEL DFI
ENGINE MANAGEMENT SYSTEMS
A Division Of Prestolite Performance

Tuning Tips for the GEN7 & THRUSTER EFI Systems

Cranking and Starting the Engine:

Note: Proper Cold Start Tuning should be done after all normal warm engine tuning is done

Cranking fuel is fuel added while trying to start the engine. It is determined by your target A/F ratio and Base Volumetric efficiency at the load points (Map Pressure and RPM) in each table where you are trying to start the motor, and your Starting Fuel Coefficient calibration table.. Base VE should be around 0.600 and Target A/F should be near 12.5:1 in the Key On Engine Off cells in each table as a starting point. The Starting Fuel Coefficient is a multiplier that acts upon the amount of fuel calculated from your Base VE and Target A/F tables. It could be as high as 200% or more, depending on the size and geometry of your engine, and the temperature at which you are trying to start the engine. After the engine is known to be started, the After-start Fuel vs. ECT Table is invoked, with its effects slowly decaying out after 30-45 seconds.

If your starting fuel coefficient is too high, your engine may struggle to start, and the air/fuel ratio will stay very low longer than it should. Your engine may struggle to keep running, and belch black smoke out of the exhaust until the effects of the starting fuel table are decayed out (around 30-45 seconds after the engine starts). Lightly opening the throttle can help, as that will have the effect of adding additional air to the mixture and effectively leaning it out. If your engine does not want to start, requires many attempts at cranking to get it to start, or starts briefly then dies, it probably needs more fuel. In this case, raise the values in the starting fuel coefficient table to provide more fuel to the engine.

Note if the engine is flooded, holding the throttle wide open while cranking will invoke Clear Flood Mode the ECM will shut off the injectors until you close the throttle plates.

Warming up the Engine:

Once the engine is started, the Warm-up Enrichment (VE Cor. vs. ECT) table controls fueling while the engine is warming up to its normal operating temperature. Increase the values in that table to add fuel to the engine while it is warming up. You should be able to watch the measured Air/Fuel ratio drop as you increase the values in this table at the current operating temp of your engine. The values in the Warm-up Enrichment table should trend toward a value of 1.0 as the engine temperature approaches the normal operating range of your engine.

Closed Loop Fueling:

The term "Closed Loop Fueling" refers to the fact the Engine Control System can operate as a closed system with respect to fuel delivery. In real time, the ECM calculates the appropriate amount of fuel to inject into the engine in order to maintain the desired air/fuel mixture ratio. Additionally, it monitors the actual operating point of the engine through the use of an oxygen sensor. The ECM then makes fueling corrections based on the *feedback* received from the oxygen sensor reading. In an open loop system, there are no modifications made to the fueling strategy based on the data obtained from an oxygen sensor. In fact, there may not even be an oxygen sensor present in the engine.

HEGO and UEGO Oxygen Sensors:

A HEGO oxygen sensor is a low-cost, narrow-range oxygen sensor that can be used to provide basic feedback about the operating point of the engine. The HEGO sensor has an output range of 0.1 to 0.9 volts, with a value of 0.45 volts equating to an air/fuel ratio of 14.5:1. Voltages below 0.45 volts indicate a lean air/fuel ratio above 14.5:1, and voltages above 0.45 volts indicate richer air/fuel values that are somewhat below 14.5:1. Ideally, the HEGO voltage should start out high (0.9 volts or so) just after the engine is started, and then decrease to around 0.45 volts as the engine temperature warms up.

When the ECM is using a HEGO sensor for fuel feedback correction, the only time that true closed loop correction can be maintained is when the engine is being operated at or around a target air-to-fuel ratio of 14.5 to 1. As the target A/F ratio gets further away from the 'sweet spot' of the HEGO sensor's range, the maximum amount of fuel that can be added or subtracted by the closed loop control system is limited linearly out to +/- 1/2 of one A:F ratio from the stoichiometric ratio (14.5:1).

When the engine is operating at more than 1/2 of an AFR away from the stoicoiometric ratio, it will be in an open loop fueling condition. This is done to prevent the control system from adding/subtracting more fuel than it should as the sensor's response becomes more nonlinear -- and less accurate. So, essentially, an engine can only run closed loop fueling with a HEGO sensor when the target A/F ratio is between 14.0 and 15.0 to 1. All other target A/F values will cause an open loop fueling condition when using a HEGO sensor.

A Wideband oxygen sensor (UEGO) is a higher-cost oxygen sensing system that has a much wider useful range than a HEGO sensor. The typical wideband oxygen sensing system has a voltage output of 0-5.0 volts representing a measured air/fuel range of about 10.0:1 to 20.1:1. Because the wideband sensor is capable of reading a much wider range of AFR values than a HEGO sensor, it usually requires some external electronics to control the sensor properly and create an accurate 0-5 volt output signal. You should NEVER connect a wideband O2 sensor directly in place of a HEGO sensor. There will always be some kind of external electronic controller that is required to exist in between the ECM and the actual sensor. Since the wideband sensor has an output voltage that can be directly converted to an air/fuel ratio, it makes tuning much easier by relating VE table values directly to an actual observed air/fuel ratio value.

Target Air/Fuel Ratio Table:

The Target Air-to-Fuel ratio table indicates the desired operating air-fuel mixture ratio for the engine. Your target Air/Fuel Ratio numbers are used to control how well you want the engine to perform versus how bad you want your mileage and emissions to be. In a stock application, most of this table will be filled in at 14.5:1 because that is the most efficient ratio for gasoline as far as combustion and emissions are concerned. Your engine runs cleanest at 14.5:1 and still makes reasonable power there as well. However, much more power can be made by running the engine at an air/fuel ratio that is richer than 14.5:1. A normally aspirated engine (non boosted) will make peak power around 12.5 to 13.2 air/fuel ratio. Typically the target air/fuel ratio numbers decrease as MAP and RPM increase. You want to make more power in those regions, so you do it by adding more fuel to the mixture as a function of a lower target air/fuel ratio number. The drawback is that the EPA stuff -- emissions and fuel mileage -- get worse at lower air/fuel ratio values.

An engine can be made to easily pass an emissions test when running at 14.5:1, but would likely fail badly when running at lower air/fuel ratio values.

Try this: at a warm idle, change your target air/fuel ratio values in your idle region to about 12.0:1. You should immediately hear the engine speed change pitch and might be able to detect a difference in the exhaust -- visually or by smell. Decreasing the air/fuel ratio at idle, should cause the engine to make a little more power, and the RPM number to increase as a result.

Volumetric Efficiency (VE) Table:

The Volumetric Efficiency of an engine is the ratio of how much air is actually present in the engine at any given time versus the maximum amount of air that can be present in the engine at that same time. The Volumetric Efficiency (VE) table provides a model of how much of your total engine displacement gets filled with air at different loads and engine speed values. This table is referenced by the ECM to calculate the actual volume of air present in the combustion chamber at any given time. The ECM then injects the correct amount of fuel required in order to maintain the current targeted Air: Fuel ratio value.

In general, if your observed air/fuel ratio is lower than your target air/fuel table values, your VE is too high. Likewise, if your observed air/fuel ratio is higher than your targeted values, the engine is lean because your VE value is too low. To change the VE Table values, you can enter a new value directly, or press the 'x' or '*' keys to change cells by any amount. To add 10%, multiply the cell(s) by 1.1, to take 10% out, multiply by 0.9.

The VE table must be calibrated very accurately in order for the ECM to be able to calculate the correct amount of fuel that the engine requires to maintain the Targeted A/F ratio value.

The final Fuel Injector pulse width value that is used to fuel the engine is determined by the fuel required by the engine and the calculated volume of air currently flowing through the engine.

Making the VE and Target Air: Fuel Tables work together:

When beginning to tune your engine, the goal is to make the air/fuel readings from an oxygen sensor consistently match your programmed target air/fuel ratio values by way of adjusting your VE table values.

Once your observed air/fuel ratio readings match your targeted readings, you may never have to touch the VE table again -- unless your engine combination changes. Measured air/fuel ratio readings should start out very low (around 10.0:1) briefly as the engine starts and begins to run. They should then drift up toward your target Air: Fuel ratio value as the engine begins to get warm. Once the engine warms up enough for closed loop fuel correction, closed loop correction will take over and your air/fuel ratio should quickly move to and maintain your targeted value with minimal correction.

Now, picture an engine having a target A:F value of 14.7:1. Imagine this engine having a wideband O2 sensor whose reading indicates that the engine is operating at 12.6:1. This would indicate that the VE table is not calibrated accurately. Based on the (incorrect) VE numbers, the ECM is injecting too much fuel to maintain the targeted A:F ratio, with the net effect being that the engine runs richer than the targeted AFR. Low AFR numbers are richer (less air per unit fuel), and higher AFR numbers are leaner. By the same logic, for any given target air/fuel ratio number, lower VE numbers will cause the ECM to inject less fuel (because the VE number indicates that there is less air present in the engine), while higher VE numbers will cause the ECM to inject more fuel. In this example, the VE numbers are too high, too much fuel is being injected into the engine, and the measured air/fuel ratio is lower than the targeted value. The VE Table numbers are only truly accurate when the reading on an O2 sensor consistently matches the Air/Fuel ratio programmed in the Target AF table.

Automatically Calibrating the VE Table:

The **Auto-cal** button on the VE table screen forces the interface software to automatically adjust the current active cell in the VE table by the current closed loop O2 feedback fueling correction value. The best way to use the auto-cal button is on an engine dyno where the engine can be operated under very stable conditions so as to allow different regions of the VE table to be programmed systematically. However, the Auto-cal function can also be used in a vehicle under carefully controlled driving conditions. At a steady cruise, drive the vehicle in such a way as to try to maintain a stable operating point on your VE table.

While maintaining steady engine operation, press the auto-cal button a couple of times.

Do that at several different combinations of MAP and RPM values. After several different points have been calibrated on your VE table, look at the VE table in the 3D graph view. You should be able to see the cells that were changed by the Auto-cal function. Edit the graph in 3D mode to smoothly connect the points created by the auto-cal function, raising and lowering the areas around those points as needed to create as smooth a VE table as possible. Remember, the VE table is a model of the airflow through your engine at different MAP/RPM points. Your table shouldn't have any sudden changes -- indicated by ridges or "holes" in the 3D view. The airflow through your engine doesn't suddenly change as MAP or RPM changes, all transitions should be nice and smooth.

Transient Fueling:

The Accel/Decel fueling table provides asynchronous Acceleration/Deceleration fueling control based on the widely-used TAU vs. MAP/ECT control strategy. Use this table to program for instantaneous fueling changes based on changes measured by the Manifold Absolute Pressure and the Engine Coolant Temperature sensors. Typically, the numbers in the table will decrease from top to bottom of the table due to increased airflow through the engine. They will also increase left to right in the table due to the changing fuel requirements of an engine as the operating temperature increases.

In an average naturally aspirated engine at operating temperature at idle, this table should contain TAU numbers generally around 80-85. When you step on the throttle, the load on the engine will increase, the Manifold Pressure will decrease, and the TAU number should decrease accordingly. A small decrease in TAU numbers equals a small amount of fuel added. A bigger decrease in the TAU numbers will add more acceleration fuel to the engine. For example, when the engine is idling, rapidly accelerating it to 3000 RPM will require a large decrease in TAU numbers to provide the additional fuel necessary to generate a large change in RPM. However, when the engine is at 3000 RPM and you want to accelerate it to 4000 RPM, you will need a proportionately smaller decrease in TAU numbers to provide the required fuel. At wide-open throttle (bottom row in the table) typical TAU numbers may be in the 32-45 ranges. Think of the TAU table as when the asynchronous fuel comes in.

Also note that the Acceleration Modifier table controls the gross amount of asynchronous fueling to add, while the TAU table provides a means to fine tune that fuel against engine operating point changes.

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The TPS Rate of Change calibration table offers the opportunity to add additional fuel to the engine based on sudden changes in the value of the Throttle Position Sensor reading. This function can be used to enhance the throttle response of an engine when used in conjunction with the standard Accel/Decel transient fueling table described above. Note that TPS calibration table value for very low TPS rate of change values under 1% *must always be set to 0 pounds per hour of fuel delivery*. Failure to do this may cause engine problems that can be very difficult to diagnose.

Ignition Control:

The Base Ignition Advance table is used for primary control of ignition timing. This table specifies the ignition advance angle -- the point in time expressed in crankshaft degrees -- that each spark plug is fired in relation to the Top Dead Center (TDC) position of each engine cylinder. Engine timing values depend on the geometry of the engine internals. Piston size, bore size, stroke length, intake manifold design, and many other factors, including the type of fuel, can all influence the correct amount of timing required for a particular application. In general, ignition timing values are at their highest when volumetric efficiency values are at their lowest. Timing values should also decrease any time that a power adder such as Nitrous Oxide, a Supercharger, or a Turbocharger begins to influence the operation of the engine.

When first firing the engine it is strongly recommended to verify that the Engine Control Module has accurate timing control over the engine. The easiest way to do this is to use the Forced Ignition Timing function to fix the timing at a desired value. From the main software screen, check the "Forced Timing" box and enter your desired engine timing value. The engine will now be held at that value for any MAP/RPM readings. You should use a timing light to verify that the actual timing measured by the timing light is very close to the value that you entered for the Forced Timing function. If it is not, you should rotate your distributor or otherwise adjust your ignition triggering system so that the programmed timing value matches the measured timing value. Make sure to uncheck the Forced Timing box when you have finished verifying your engine timing values!

Idle Control:
The Target Idle Speed table is used to control the desired engine speed vs. the reading from the engine coolant temperature sensor. Typically, you want to have the engine idle at a higher speed when it is cold in order to warm the engine up quicker. This table is only used when the engine is considered to be in Idle Mode having a very low Throttle Position Sensor reading.

Once the throttle is opened, the Idle control strategy shifts to Throttle Follower mode. The Throttle Follower calibration table sets the amount of bypass air available via the IAC port when you are not idling. It can be used to control the amount of time that it takes for your engine to transition down to its target idle speed after you take your foot off the accelerator.

The ECM uses the Idle Spark Control calibration table to maintain Idle quality vs. varying temperature values. It uses timing to fine tune the measured idle speed values when the engine is operating within +/-160 RPM of the target idle speed. When the engine is operating below the targeted idle speed value, the ECM can add timing to the engine in order to drive the engine speed upward toward the targeted value. Likewise, if the engine is idling too high, the ECM can be programmed to retard timing in order to lower the engine speed down toward the targeted value. The IAC control loop tuning table on the Idle Configuration screen controls how aggressively the ECM makes adjustments to engine timing and IAC position in order to maintain the targeted idle RPM value.

The Actual IAC position should be at 5-10% on a warm engine idling under very light load. In some cases, you may have to adjust the closed position of your throttle blades in order to get the ECM to control the idle speed properly. Typically, there is a set-screw on most throttle bodies that will allow you to open or close the throttle blade(s) by a very small amount in order to control the volume of bypass air that gets into the engine when your throttle is in a fully-closed position. From the Target Idle Speed screen, and with then engine operating at a warm idle, adjust the set screw until the "Actual IAC Position" reads about 5-10%.

If possible, watch the actual IAC position as you are adjusting the set screw, and you will be able to see it rise and fall as you open or close the throttle blades. Opening the throttle plate will decrease the "Actual IAC Position" Closing the throttle plates will increase the "Actual IAC Position". Once the throttle blades are adjusted and the IAC position is in the desired location, you will likely have to reset your Throttle Position Sensor Open and Closed set points.