U-Tune

Aftermarket Performance Tuning

by

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INTRODUCTION:

Welcome to the world of aftermarket performance tuning. Once you understand some basic tuning methods and techniques, you will be able to successfully tune your modified vehicle. Proper tuning will help you to achieve optimum performance and eliminate poor drivability.

This guide focuses on simple techniques to tune your vehicle with the use of a programmable calibrator or what is sometimes called a piggyback computer. We will focus on the use of the Split Second Fuel / Timing Calibrator. These tuning techniques will also work with most of the programmable calibrators on the market today.

Please read through this entire guide and any other info you can find before you start tuning. Remember, you can make your vehicle more enjoyable or you can cause damage if tuning is not done correctly.

Buckle up, BOOST ON!!

HOW IT WORKS:

A programmable calibrator is a device that is installed "inline" in the vehicle wire harness between the various sensors on the engine and the stock Engine Control Unit (ECU). The programmable calibrator modifies these signals from the sensors and then passes them on to the ECU. By modifying these signals we can trick the ECU into doing things a little differently than it normally would thus giving us some control to retune a modified engine for better performance and drivability.

The programmable calibrator can modify a signal, clamp a signal, or delay a signal.

Signal Modifiers:

Signal Modifiers work by taking a signal and changing it in some way. For example, the signal from the Mass Air Flow (MAF) is normally a voltage from 0-5 volts depending on the amount of air entering the engine. If the signal or voltage is altered we can make the engine run richer or leaner in some cases. On Toyota engines, the voltage increases as the air flowing through the sensor increases. If we intercept the signal and increase the voltage we can make the ECU think there is more air coming into the engine then there is. This will make the ECU inject more fuel then it normally would and cause a richer mixture. The same works in reverse to lean the mixture. On some vehicles the voltage from the MAF is inverted, meaning it decreases as the airflow increases.

When managing the mixture there are limitations. When the ECU is operating in CLOSED LOOP mode, it will fight you to maintain the mixture at a preset mixture level. We will discuss more about this later in the section on OPEN and CLOSED LOOP mode.

Signal modifiers can be voltage or frequency based; however in the Toyota world we use mostly voltage or current modifiers.

Signal Clamps:

Signal clamps can be either frequency or voltage based. They limit a signal to a preset level so it does not go any higher, or drop below a certain level.

You may see signal clamps used to clamp signals like engine coolant sensor signals, and vehicle speed sensor signals. Engine coolant sensors are usually voltage based where devices like vehicle speed sensors are frequency based.

URD markets a device called a Speed Unlimiter for sanctioned off road racing only. This device clamps the signal that comes from the vehicle speed sensor. The signal from this sensor is frequency based. As the vehicle speed increases so does the frequency. When the frequency reaches a certain value preset in the ECU it activates and cuts fuel to the engine to limit the top speed of the vehicle. If we intercept this frequency signal and stop it from increasing just below the activation point of the limiter programmed into the ECU, the speed governor can be thwarted.

Once the clamp level is reached the Speed Unlimiter replaces the signal from the sensor with one generated by the Speed Unlimiter that no longer increases in frequency so the ECU does not know the vehicle speed has reached the activation point of the speed limiter and unlimits the vehicle top speed. This is generally how a frequency clamp works.

Delaying a Signal:

By intercepting a signal and delaying when it gets to the ECU we can alter time critical signals. The most typical way this technique is used is to control ignition timing.

Normally on modern vehicles there is a magnetic sensor that sits close to a ring that is attached to the crankshaft and this ring has notches on it. As each of these notches passes the magnetic sensor it will induce a pulse into the sensor wire. These notched rings may have a notch or two missing at one point or will not have any notches until a certain point. It is this difference in notches and the signal it generates that tells the ECU what position the crankshaft is in. The ECU needs this information to decide when to fire the spark plugs and fuel injectors.

Now if this pulsed signal is intercepted and delayed before it is allowed to continue to the ECU we can change when the spark plugs are fired. If we delay it a little we can retard the ignition timing. If we delay it a whole bunch, say 350 degrees, we can end up making the spark plugs fire 10 degrees sooner, making it advance the ignition timing.

TUNING TOOLS:

The term programmable calibrator means in line with the ECU. Remember it is installed between the various sensors and the ECU and it recalibrates the tune by altering the signals.

Most all of the programmable engine calibrators generally work under the same concept and the techniques laid out here will generally apply to all of them. This guide will focus on the Fuel Timing Calibrator (FTC) by Split Second and it's R4 tuning software.

Tuning cannot be done without the necessary measurement tools. You will need two basic tools to tune your programmable engine calibrator, which we will refer to from now on as the FTC. For tuning the CLOSED LOOP you will need a scan tool that will allow you to interface with the stock Engine Control Unit (ECU). The scan tool to tell us when the ECU is in OPEN LOOP or CLOSED LOOP mode and what the FUEL TRIMS are.

For tuning OPEN LOOP you will need a wideband sensor and controller. The wideband unit will give us critical air/fuel ratio information.

Scan Tool:

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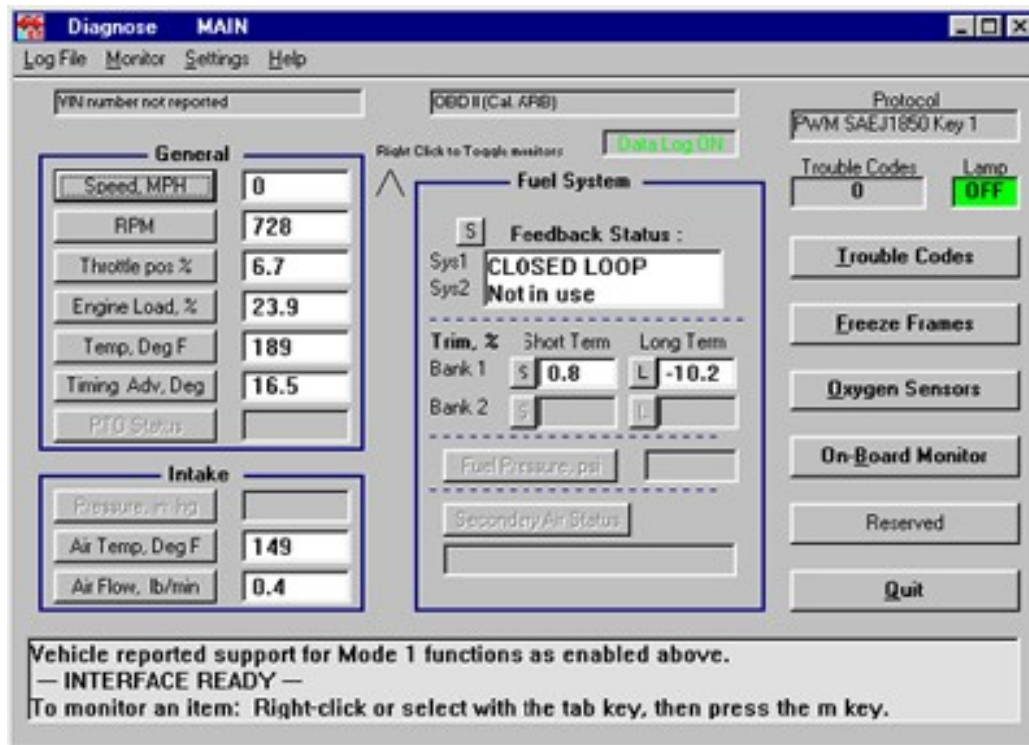
This is the main page from the BR-3 OBDII scan tool.

URD has looked at most scan tools on the market. The one that is the least expensive and provides the needed information is the one from OBD Diagnostics (http://obddiagnostics.com). The BR-3 OBD scan tool sells for $88.

The scan tool connects to the OBD diagnostic port on your vehicle. It is located under the dash on the driver's side. It also connects to your Windows PC via its serial port.

You are going to need to connect the scan tool and the FTC to your PC at the same time. They both use the serial port. The newer notebook PCs do not have a serial port, so you will need a USB to serial converter to take advantage of the USB ports to give you enough connections. URD has USB to serial converters for sale on the URD website if you need one or two of them.

Another converter choice is a dual serial converter that slides into the PCMCIA or PC card slot on the side of your notebook PC. URD uses the one from a company called Socket (http://www.socketcom.com). I suggest you get the ruggedized one with two serial cables. This thing has proven to be flawless, but it is much more expensive. You can find one on Ebuyer for about $170.

> *TIP: The more things you have displayed on the scan tool the slower the refresh rate is. When tuning only display the Feed Back Status (ECU mode) and the fuel trims.*

Wide Band Sensor Display Unit:

The Innovate Motor Sports LM-1 Wide Band Unit with data logging.

Using a wideband unit is a very important tool for tuning your OPEN LOOP map. Just a couple of years ago you would have to spend thousands of dollars for one of these things. The quality has improved and prices have really come down, and they are now very affordable.

URD carries two different brands of wideband units, the LM-1 from Innovate Motor Sports and the M-300 and M-500 from PLX.

If you have purchased one of URD's complete Supercharger Performance Upgrade Kits and would like to purchase a wideband unit for tuning please contact URD for current pricing and any special offers.

The wideband sensor is a high-grade oxygen sensor that reads the oxygen content of the exhaust and reports to you with a digital display the air/fuel ratio of the mixture entering the engine. The most important thing is that the sensor should be installed in the exhaust so it can sample the exhaust gas BEFORE the catalytic converter. This is so it can get an accurate reading of what the air/fuel ratio reading really is. The catalytic converter by its very nature will alter the oxygen content of the exhaust and throw the reading off.

URD sells stainless steel exhaust O2 sensor bungs and plugs for welding in the exhaust before the catalytic converter. Do not try to use a mild steel bung from some exhaust shop because it will rust very quickly and you will find it of little use to you.

> *TIP: When welding in the bung for the wideband sensor, do not weld it in the 6 o'clock position or straight down. Condensation in the exhaust will crack the sensor element if it comes in contact with the sensor. 12 o'clock is best, but there usually is not enough room. I usually put them in from the 8 to 4 o'clock position.*

Data Logging:

Data logging is one of the latest things to come along and has become affordable for those that want to tune their own vehicle. URD offers two different wideband units that have data logging, the PLX M-500 and the Innovate Motor Sports LM-1.

The PLX M-500 uses Blue Tooth wireless technology to connect the wide band data logger to your Windows PC.

The Innovate Motor Sports LM-1 can data log many different things on its own, but if you combine that with their new AuxBox, you have an incredibly powerful data logging capability including its own built in dyno using accelerometers. It will allow you to log manifold pressure, RPM, intake air temp, throttle deflection, G-force acceleration, EGT, and many other things. You can capture and play back enough channels to make NASA jealous.

The basic idea with data logging is to capture data that will assist you in identifying specific map cells on your map that could be adjusted for better performance.

The chart from a chassis dyno is basically a three-channel data logger. It just logs horsepower/torque, RPM and Air/Fuel Ratio (AFR). You can log more then that at home and with the accelerometers in the AuxBox you may have more capability in your garage.

You should take the time to go to the Innovate Motor Sports web page and view the informative videos you will find there (www.TuneYourEngine.com).

Chassis Dyno:

Your calibrator should be road tuned before you even think about dyno tuning it. Most chassis dynos are inertial types, like DynoJet, and are only useful for tuning

at full throttle. You MUST, completely road tune your closed loop map before you dyno tune full throttle on a dyno.

Many tuners will disagree with this, but we have found that the CLOSED LOOP map will have a slight affect on full throttle, and how the ECU applies its internal fuel trims to the full throttle fuel mix. If you tune full throttle first and then go back and play with the CLOSED LOOP, you will find that your full throttle AFR will change, and you will have wasted a dyno tuning session.

Another thing we have found is that your truck may perform one way on the dyno and then perform differently on the road. You can dial in an AFR that gives you the best power on the dyno and then go out on the road and find that the AFR at wide open throttle is very different.

The trick here is to tune your truck on the dyno and find out what AFR gives you the best power on the dyno at different RPMs. Take very careful notes.   Now after your dyno tuning session go out on the road and see if your AFR stays the same; if it does you are golden. If not you can then tweak the map to restore the AFR that gave you the best power on the dyno. Now you can be confident you have the best tune possible.

> *TIP: See if you can use an old style glass PC monitor during your dyno run while connected to the FTC. When the run is being made, trace the cursor's movement with a grease pencil right on the screen. That way you will know EXACTLY what cells were active during that run. Now compare your dyno chart with the AFR graph and you can very quickly target the specific cells that need to be changed. Crude, I know, but it really cuts the dyno tuning time and will save you a lot of money!*

Dyno tuning is not necessary. We have found that if you road tune your TRD Supercharged equipped 5VZ-FE engine to 12.0:1 at full throttle you going to make very close to maximum power.

ECU OPERATING MODES:

There are two main operating modes that the stock ECU operates in, OPEN and CLOSED LOOP. There is a third minor one, called FUEL CUT. These modes deal with controlling the fuel mixture of the engine. The basic difference between two of the modes is whether or not the ECU is using feedback from an oxygen sensor in the exhaust to make fine adjustments to the fuel mixture. When it is using feedback from the oxygen sensor to adjust the fuel mixture it is in CLOSED LOOP mode. When it is not using feedback from the oxygen sensor it is in OPEN LOOP mode. When the ECU completely or partially cuts off fuel to the engine, that is called FUEL CUT.

Closed Loop Mode:

The manufacturer programs the stock ECU with a lookup table that it uses to determine how much fuel to inject into the engine. It uses engine RPM, throttle position, the amount of air by weight, the temperature of the air entering the engine, and the engine coolant temperature to determine how much fuel by weight to inject into the engine. This initial amount of fuel is fine-tuned based on the reading from the oxygen sensor. The adjustment it makes to the standard lookup table is called fuel "trimming". When the ECU is making these fine adjustments to the fuel mixture using feedback from the oxygen sensor, the ECU is operating in CLOSED LOOP mode.

When the ECU is operating in CLOSED LOOP mode you do not have control over the mixture with a programmable calibrator. If you try to increase the MAF signal to make it run richer, the ECU will just trim the fuel back out to keep the mixture near the preset 14.7:1 air fuel ratio by weight. It is important that this is clearly understood. For the most part you cannot change the mixture while the ECU is operating in CLOSED LOOP mode. If you try the ECU will resist keeping the mixture where it thinks it is supposed to be.   There is a limit to how much control authority the ECU has to adjust the mixture. If the maximum fuel trim limit is exceeded and the ECU looses control of the mixture in CLOSED LOOP mode it will set a check engine light. You must work with the ECU when tuning CLOSED LOOP and not against it. The ECU will win every time.

What you can control with a programmable calibrator in CLOSED LOOP is the amount of trimming the ECU has to do. You will enjoy the best drivability when the fuel trims are minimized throughout the CLOSED LOOP region.

Open Loop Mode:

When the ECU is not using feedback from the oxygen sensor to adjust the mixture it is operating in OPEN LOOP mode. When you first start the engine, it will start up in OPEN LOOP mode because the oxygen sensor has not gotten hot enough to start the chemical reaction needed to provide a usable signal. Under some conditions during deceleration with the throttle closed it will switch to OPEN LOOP, and finally, when the throttle is advanced to some preset point, usually around 80% or higher, or held at a high throttle position for a given time, the ECU will switch to OPEN LOOP mode and apply enrichment of the fuel mixture.

The important thing to know is that when the ECU is operating in OPEN LOOP mode it has no idea at all what the mixture is. It can be richer than it needs to be killing power and damaging the engine and catalytic converters, or way too lean causing serious engine damage in a short period of time. It is OPEN LOOP tuning where you can unlock hidden power or destroy your engine quickly.

Fuel Cut:

A third ECU mode is called FUEL CUT. The ECU will cut fuel to the engine in three conditions. The ECU will cut fuel to the engine when you attempt to exceed the maximum safe engine RPM to protect the engine. It will cut the fuel to the engine if you attempt to exceed the maximum safe tire speed rating programmed into the ECU. It will also cut fuel to the engine if you are decelerating with the throttle closed above 1500 RPM.

When tuning you are most concerned with deceleration FUEL CUT. You want to make sure that the ECU makes a smooth transition from FUEL CUT deceleration back to CLOSED LOOP, or to a CLOSED LOOP idle if the vehicle is stopped.

I tuned a customer's truck with one of URD's Supercharger Performance Upgrade Kits on it. The customer was very excited about the dramatic increase in performance, but the next day he called with a concern. He has a PLX wide band unit hard wired in his truck and he told me that his engine was seriously leaning out at high RPM. He said that he tested this about 20 times and it was always the same. This is kind of like hitting your thumb with a hammer. If it hurts really badly the first time, you do not need 20 more times to confirm it, hurt hurts…

What the customer was doing is exceeding the maximum safe engine RPM and the ECU was engaging FUEL CUT to protect the engine. The ECU begins to cut fuel to different cylinders and there is no combustion. It just pumps air through the engine and into the exhaust. This air mixes with the exhaust from the cylinders that are firing, making the exhaust stream full of oxygen and causing a very lean display on the wideband unit.

TUNING:

The very best way to start your tuning is to learn how your vehicle operates while STOCK. Before you start making substantial modificati ons and installing larger injectors, fuel pumps, and a programmable calibrator, take some time to learn how your vehicle operates.

Hook up the scan tool and wideband unit, drive the vehicle normally and monitor the fuel trims, air/fuel ratios, and most importantly how the ECU switches from OPEN LOOP to CLOSED LOOP operation.

A few of the troublesome areas are how it transitions from OPEN LOOP cold and hot starts to CLOSED LOOP idle, and how it transitions from OPEN LOOP deceleration and stopping to CLOSED LOOP idle.

Generally we want to mimic much of the stock operation in these areas. By observing these things before you start installing all your modifications, you will learn valuable information and greatly speed up your tuning time. However, most people install everything first, and then try to figure out how to tune, or hope it will not need tuning.

Hardware Checks:

Before you get started tuning your vehicle, you should check some things first:

1. First, verify that the throttle plate is opening all the way when the accelerator pedal is all the way to the floor. If it is not opening all the way, the engine will not make full power, and it will delay the ECU switching into OPEN LOOP mode. You would be surprised how often this occurs.

2. Inspect the exhaust system. It must be leak free in the area before the catalytic converter. If it leaks in this area, it can cause faulty readings by the oxygen sensor and your wide band unit and can really frustrate you and your tuning efforts. If you have erratic fuel trims this is one thing that can cause it.

3. Make sure the vacuum line on the FTC is properly connected to a port that will allow both positive and negative manifold pressures to be read.

4. Examine the overall health of the engine. If you see oil coming out of the engine breather, smoke, or general state of disrepair, this engine might be on its last leg. You do not want to be the one operating or tuning it when it comes apart. You will get the blame every time.

5. Check the engine oil. If it is low or looks really cruddy, think twice about tuning this vehicle.

6. Make sure that the main air induction tube is secure and leak free. If air is allowed to enter the engine that does not go through and get read by the MAF sensor, you will have a very frustrating tuning session.

7. If the engine is equipped with the old style switching type O2 sensor check the waveform with the scan tool and make sure it nice and healthy. An old, tired, or bad O2 sensor will result in a poor CLOSED LOOP tune that maybe very erratic. If you find that a replacement O2 sensor or air/fuel ratio sensor is needed, you can find them for a very good price on the URD website.

8. Check the air filter and the MAF sensor. If the filter is cruddy, replace or clean it. If one of those cotton gauze type filters has been used, you may want to inspect the MAF for contamination before tuning. If it is dirty it will throw your tune off and cause erratic operation. The MAF sensor can be cleaned with non-residue electronic parts cleaner. When using a filter that is recharged such as a K&N, be sure to use a minimum of oil to avoid contamination of the MAF sensor element.

Start Tuning:

Before you go any further you should stop and locate the technical manual that came with the programmable calibrator that you have installed in your vehicle. Read it completely so you have a clear understanding of its operation as well as the manual that came with the tuning software you are using.

Taking a little time here could save you a lot of heartache down the road from a very costly mistake.
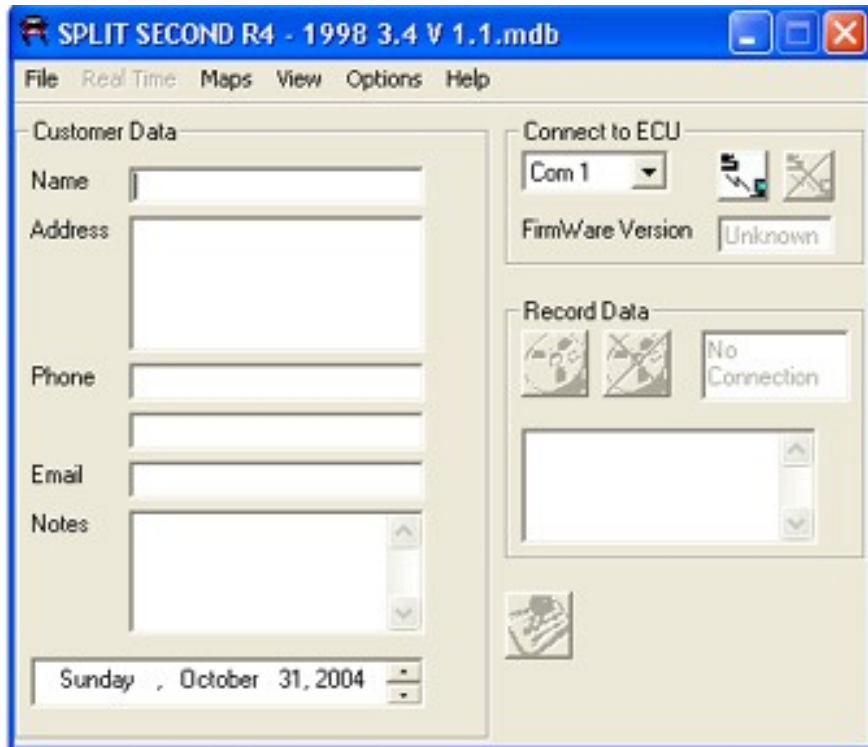
This is the main page of the Split Second R4 tuning software.

Lets get started tuning your vehicle. The first thing to do is the initial setup of the tuning software. Open the R4 Tuning software in your Windows PC and:

1. Click on FILE in the menu and select NEW CUSTOMER.

2. TYPE whatever name you want for the new file you are creating and click SAVE.

3. Click FILE and OPEN CUSTOMER.

4. SELECT the file that you just named.

This will open a new map in the R4 Tuning software. Now you must configure the basic settings:

1. CLICK on OPTIONS in the menu.

2. Select SYSTEM SETTINGS. In DISPLAY MODE select VACUUM/PRESSURE and in APPLICATION select PROGRAMABLE SIGNAL CALIBRATOR. Now close that window.

3. Click on OPTIONS in the menu.

4. Select ENGINE SETTINGS, then select the number of cylinders for your engine, and 4 Stroke. Then close out that window.

5. If and only if you have an E model FTC, click on OPTIONS in the menu.

6. Select OUTPUT SETTINGS.

7. Set OUTPUT B MODE to OVER PRESSURE and then set OVER PRESSURE to 4 PSI and close out the window.

URD sells the FTC calibrators in two configurations. It is sold by itself and also included in the Supercharger Performance Upgrade Kit. The FTCs include in the kit are preloaded with a "startup" map to give you a head start on your tuning. If you got your FTC in a complete kit you will need to pull the preloaded map out of the FTC to your PC. To do this:

1. Connect your PC to the FTC with a true serial cable. Select the proper serial port. Turn on the vehicle ignition key to power up the FTC, and then click on the CONNECT TO ECU button. This will connect you to the ECU. The disconnect button should become active once the connection is made.

   TIP- Do not connect your Windows PC to the FTC until AFTER the PC has finished booting. If it is connected while it is booting up, the Windows "Plug-N-Play" will think the FTC is a mouse and try to install it as such. This will conflict with your current mouse and you will see the cursor go nuts and constantly jump all over the place rendering your PC useless. If you have this happen, disconnect from the FTC and reboot to clear the problem.

2. Click on MAPS in the menu and select FUEL MAPS. This will open the map page. Map A is the fuel map, map B is the ignition timing retard map.

3. In the upper left corner of the map page are two buttons. One will write data to the ECU (FTC) and one will read data from the ECU (FTC). You want to click on the "READ DATA FROM ECU" button. This will pull the map from the FTC to your PC so you can start tuning.

4. Go back to the OPTIONS menu on the main page and make sure none of the previous settings have changed. These settings DO NOT down load from the FTC and if you don't have them properly set, when you write back to the FTC it will change them in the FTC and you will have some strange things happen that you do not want.

If your FTC came preloaded with a "startup" map, I recommend that you save a copy of it as a backup in a safe place before doing any editing. This way you can get back to where you started if necessary.

If you did not buy the FTC in a complete kit from URD you will have to make your own initial map to tune from. Split Second loads a diagnostic map in the FTC to test for proper operation before it is shipped. You must clear this and install a map to start your tuning from. Here is how to do this:

1. Connect to the FTC using the above steps stopping with number 2 in the section just before this one.

2. Select map A and then click in the upper left corner of the map. Like a spreadsheet program this will highlight every cell in the map.

3. Find the button called "FILL SELECTED" and CLICK on it.

4. TYPE 10 in the box that opens and click OK. This will put a value of 10 in every cell on the map.

5. Select map B, and do the same as above filling all the cells with a value of 0 (zero).

6. Now, locate the second button from the left labeled "WRITE DATA TO THE ECU (FTC)" and CLICK on it. This will write the map you just made to the FTC. It will take a few seconds to complete.

Start the engine and look for the blue curser that highlights the cell on the map that it is reading from. Blip the throttle and make sure the cursor moves up and down as the RPMs change, and move left and right as the manifold pressure changes.

Before you start tuning pull up the REAL-TIME function located in the main menu and SELECT the ALL screen. Make sure that the displayed RPM and manifold pressure match the actual values for the engine at idle. They should be approximately 800 RPM and –20 inHg. If this is not working correctly start your trouble shooting now.
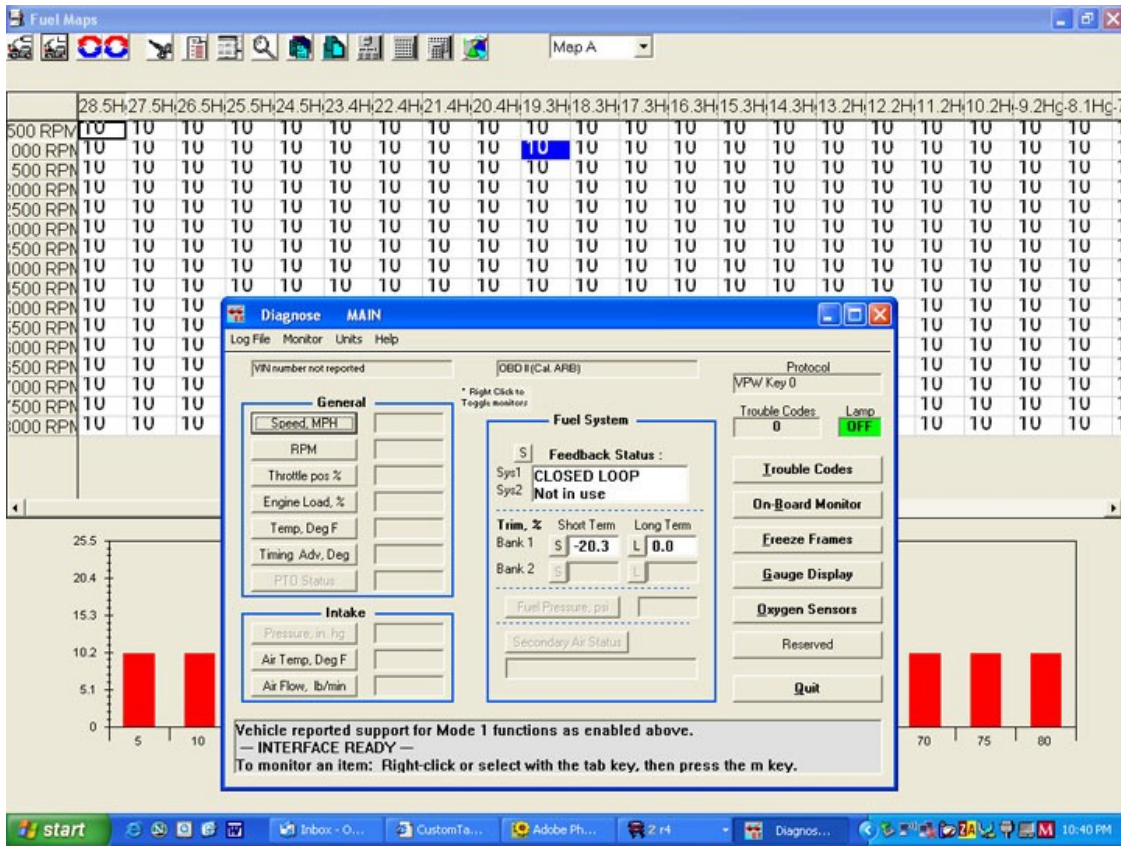
A value of 10, which is neutral for the fuel map, was used as a starting point. Within seconds of the O2 sensor coming online, the short term trim maxed out at –20.3%. If you see this much of a change that fast, shut down right away. You now know that you have to pull a bunch of fuel out. The next attempt was using a value of 9.5. That still was a tad rich, so a value of 9.4 was used and that turned out to be the magic number for this vehicle for a base map to tune from.

Now connect the scan tool to the PC and the vehicle. Start the engine and overlay the scan tool display over the fuel map (map A). Now right click the system status button and the bank 1 short and long-term buttons (some vehicles use a second back of sensors, like the Camry and Tundra). This will tell you what mode the ECU is operating in and what the fuel trims are. Once the vehicle has warmed up completely it should report CLOSED LOOP mode and you should see the fuel trims come alive.

What you are looking for is the direction of the short and long-term fuel trim idle. If you have installed larger then stock injectors the ECU should recognize that more fuel is going in than there should be and start pulling that fuel out. This will be reported by NEGATIVE TRIM values. Once they stabilize, see what the value is. If it is negative you will need to decease the cell value. If it is positive you will need to increase it. You goal here is to find the cell value that will drive both fuel trims to near ZERO.

> *TIP: Changes to a map do not become effective until that map change is written back to the FTC. If you shut down the scan tool when writing a map back to the FTC you will find that the write speed will almost double.*

On the fuel map (map A), a cell value of 10 is neutral. It is not altering the signal from the MAF. If you reduce the value less then 10, you are leaning the fuel mixture. A value of more then 10 you are richening the fuel the fuel mixture.

Now you will need to decide on a cell value to input to try to get the fuel trim to near zero. Say you have a negative short term trim value of –15% and a negative long term trim value of –10%, they combine together to give you a –25% value. You can see the map is way too rich at idle. So, now put a value of 9.5 in the area that the cursor is in at idle. Try that and see if it was too much or not enough. Keep trying until you nail it down, making small changes at first.

Because the long-term fuel trim is slow to respond, you will not be able to get both the short term and long term fuel time to zero during your tuning session. Your objective should be to have short term and long-term values that are equal magnitude with opposite sign. For example, trim values of +10% and –10% will average close to zero after several drive cycles and over 100 miles of driving.

Now you will need to write that map change back to the FTC. Do this by shutting the engine off and then turning the ignition key back to the on position to power up the FTC. Select the "WRITE DATA TO ECU (FTC)", and the new map will be written to the FTC.

Once the writing process has been completed, turn the ignition key all the way off for a few seconds and then restart the engine. If you do not wait a few seconds before restart you may get a CHECK ENGINE LIGHT.
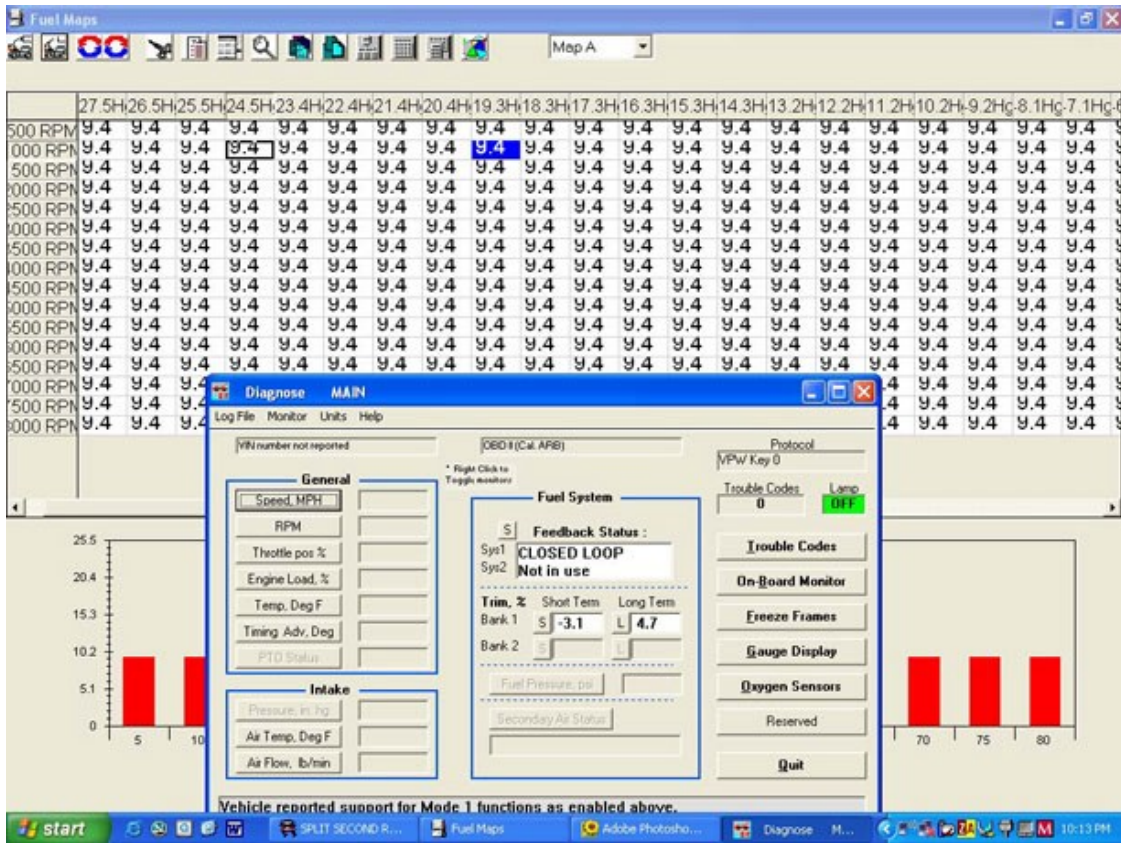
In this figure a fuel map value of 9.4 was tried for a base map setting. The –3.1% short term and the positive 4.7% long term are added together to give a positive 1.6% trim correction. Over time the ECU will adjust the short and long term trims more to a neutral setting and reduce the difference between them. This is a perfect starting place to use as the base map to start tuning from.

Once it is started, watch the fuel trims again and see where they stabilize. Keep altering the map values until you get the map to near ZERO on the fuel trims. Remember, that both trims add together and a negative will cancel out a positive. Once you get a good number, you will want to put that number or cell value in every cell on the map. Do this by highlighting every cell on the map and use the fill-selected button. Once that value is in every cell write that new map back to the FTC.

Now you have a base map to start tuning from. The best way to proceed is to have someone drive your vehicle in a safe place while you monitor the fuel trims and decide where to make map changes. In CLOSED LOOP it is best to make a cell value change in the entire pressure column where a change is needed. You do not need to go to every cell in that pressure column. You will notice that very few cells will actually be used in any pressure column, but every cell must be filled with valid cell value.

As you advance the throttle from idle the cursor will rapidly move right and then as the RPMs build it will move downward. Generally the cursor will make a large reversed S pattern across the map. You will see that there are areas that are never touched by the cursor, but all cells much be filled just in case you get in there unexpectedly and you do not want the engine to stumble.
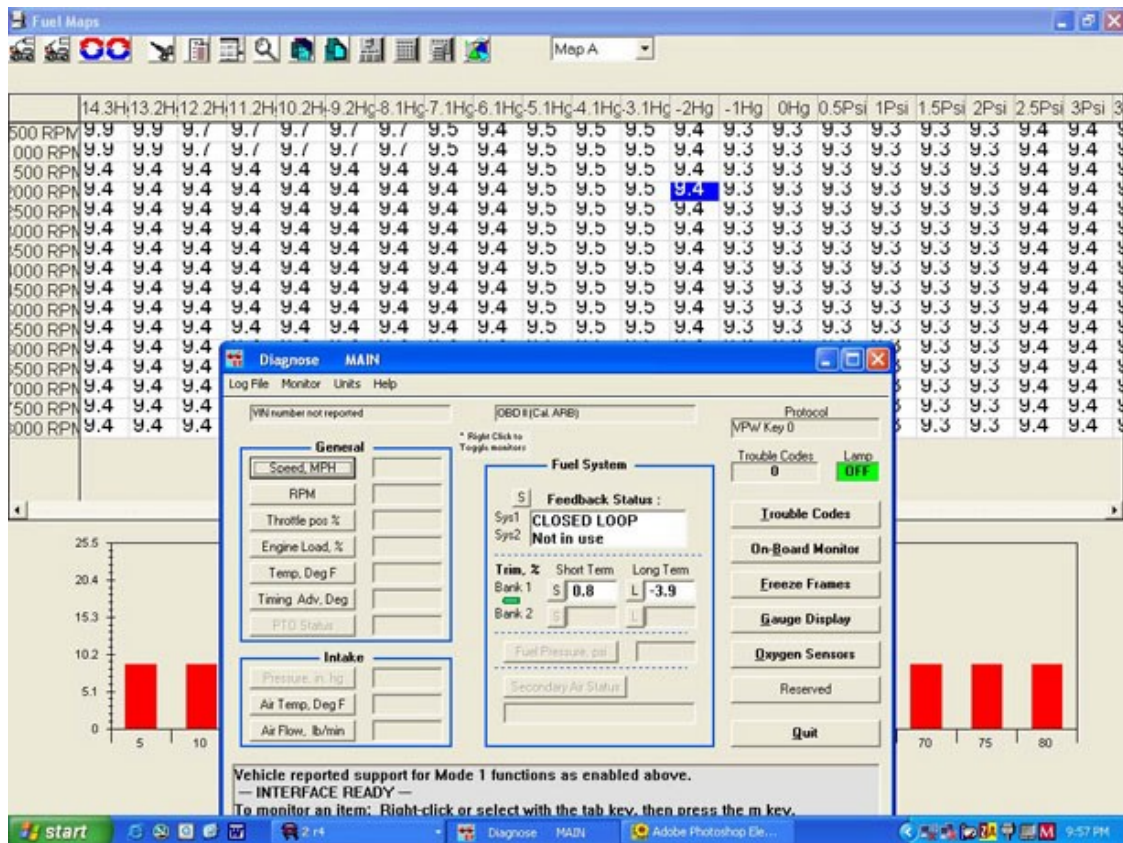
In this figure, you can see the engine is cruising at 2000 RPM and pulling 2" of vacuum. The short-term fuel trim is ZERO, and the long term is –3.9%. I tuned this vehicle a year before this screen shot was taken. The map is right on the money!

Proceed cautiously and keep increasing the manifold pressure as you dial in the map. Take baby steps here and progressively move to higher pressures. Eventually you will reach the boosted regions of the map.

At some point near full throttle the scan tool will report that the ECU has switched into "OPEN LOOP" mode. Once it has switched to OPEN LOOP, you will need to use the wideband unit to tell you what the Air Fuel Ratio (AFR) is. On your initial map you are shooting or an AFR of about 12.0:1 in OPEN LOOP.

There will be some cells on the fuel map where it will sometimes be in CLOSED LOOP and other times it will be in OPEN LOOP. In that area you may have to

split the difference in what you need for CLOSED LOOP tuning and OPEN LOOP tuning.
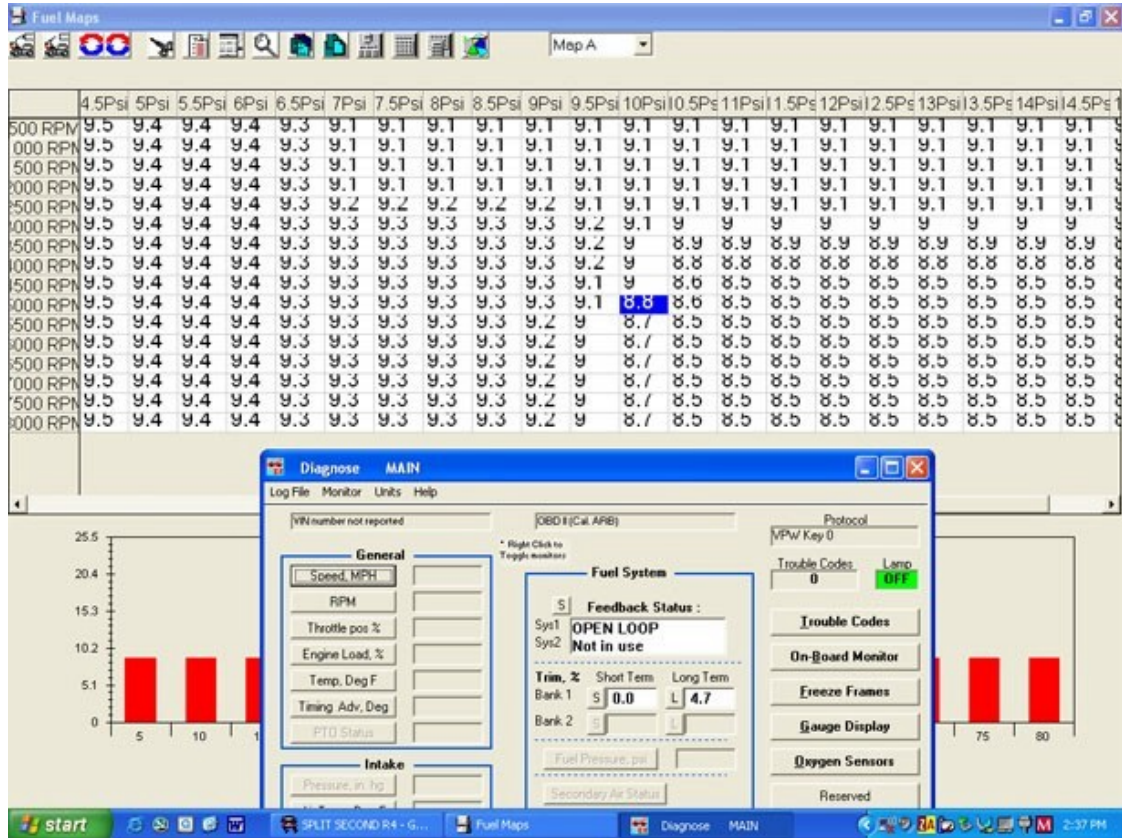
This is the vehicle at full throttle. The scan tool is reporting OPEN LOOP and the wide band unit is displaying 12.1:1 AFR. On this vehicle fuel had to be pulled out to keep it from getting way to rich on the top end. Other vehicles you will have to add a bunch to keep them from going lean. Every vehicle and the tune it needs will be different.

In the OPEN LOOP area you want to get cell specific with your tuning. Generally in CLOSED LOOP you will make changes in the entire pressure column when making the base map. Then later if you identify any drivability issues, may then need to get cell specific in CLOSED LOOP. The areas to focus on are the transition from deceleration to CLOSED LOOP idle, cold and hot starts to CLOSED LOOP idle.
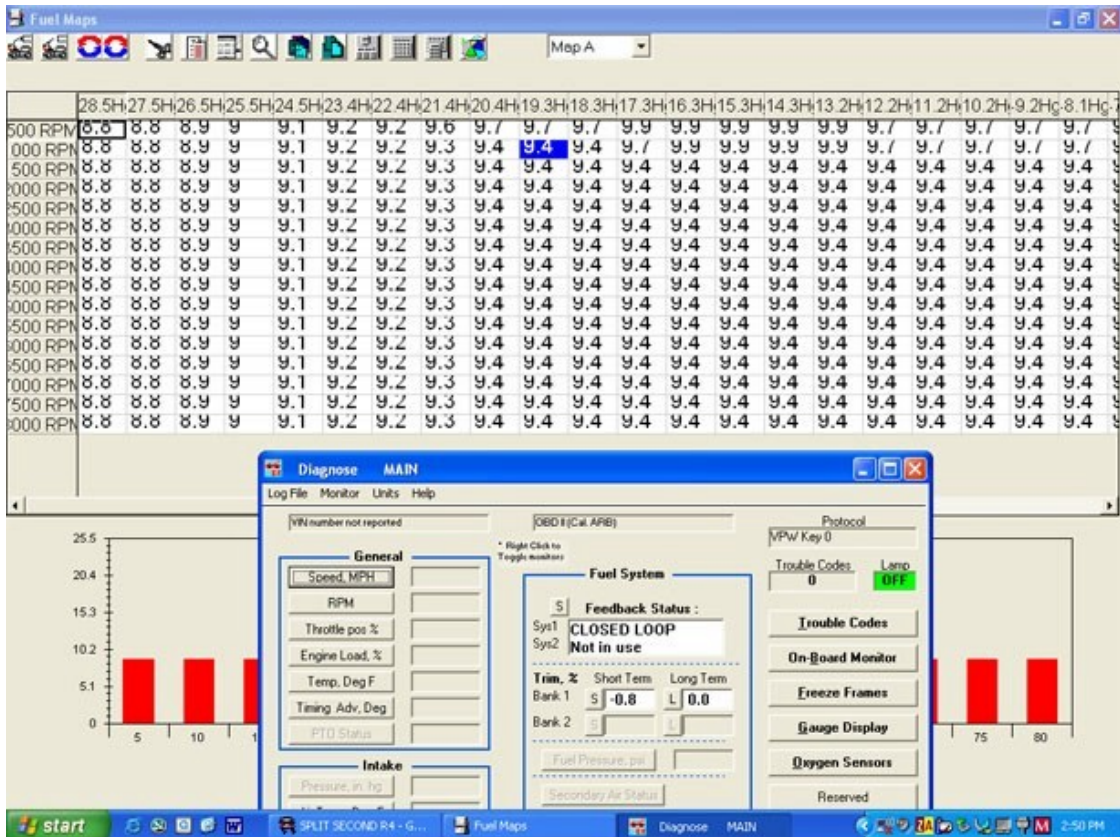
This is the completed map at idle. Check out those fuel trims! The entire CLOSED LOOP is tuned, OPEN LOOP and full throttle is tuned, deceleration is tuned, and the vehicle makes the smooth transition from hot and cold start OPEN LOOP to CLOSED LOOP idle. This vehicle has had an impressive increase in performance, and most importantly, has NO bad manners or drivability issues. The boost induced spark knock has been eliminated, and the high RPM lean out is gone for good. It drives like the supercharger came on the vehicle from the factory.

Once you feel you have a very good CLOSED LOOP map dialed in, test your work. Do this by removing the EFI fuse from the under hood fuse box behind the battery for about 10 minutes. This will erase the volatile memory in the ECU including the fuel trims. Now start it up and see how close the fuel trims fall back in to the near zero value you had before. If not make some adjustments and try it again. Once the fuel trims fall back to the near zero value consistently, you have succeeded in setting up your initial map. Be sure to save a copy of this map as a back up. You may need it later when you decide to over tune the map into a mess. We all do it and it cannot be helped.

> ***TIP: When you are going to save a copy of a map as a back up, you should first use the COMPACT DATABASE function found under FILE in the main menu. Close the "customer" and then use the COMPACT DATA BASE command. This eliminates all the extra data***

that the FTC records in its data log file. You will find that the file will grow really large as your tuning session goes on.

TIP: You can email a map you made to someone else. Before doing so you should use the COMPACT DATA BASE command and then ZIP the file to a compressed folder. Most virus programs will kill an FTC map if sent as an email attachment if it is not ZIPPED to a compressed folder.

E Model FTC:

The E model FTC has the Split Second EGO Signal Conditioner (ESC) function built into it. This device is used on the older trucks with the old style O2 sensors. The older trucks suffered from boost induced power surging in low boost due to the slower cycle rate of the older ECUs and O2 sensors.

I have found that Toyota vehicles newer then 1999 do not suffer from this low boost induced power surging, so URD does not recommend the more expensive E model FTCs for vehicles 1999 and newer 5VZ-FE engines.

When activated the ESC replaces the signal from the O2 sensor with a signal that keeps the ECU from trimming the fuel mixture. When the ESC function is active, it will act like it is in OPEN LOOP, but the scan tool will report that the ECU is still in CLOSED LOOP mode. You will have to tune the fuel mixture in this condition with the wideband unit and not the scan tool. If you have tuned your wide open throttle (WOT) to 12.0:1, then tune the area of the map that covers the ESC operation richer, say 11.0:1 and then have it lean down to 12.0: in true OPEN LOOP. This will eliminate the boost induced power surging, give you a very strong torquey mid range, and make a very smooth transition to true OPEN LOOP.

Some people have reported that the ESC function will kick out and go lean if you stay in the activation range of the ESC too long like going up a mountain. We have never seen this at URD. The reason maybe that we set this range to a AFR of 11.0:1 to 11.5:1 and if it does lean out a bit, you are still very safe. Just be aware of this and watch for it. If you see it and it becomes a problem for you try setting the activation point higher so you are less likely to activate it. As long as you are not getting the boost induced power surging you are fine setting the activation point higher. You can turn it off by setting the activation point higher then you can possibly reach like 15 PSI.

The activation point for the ESC function is found in the OPTIONS menu and OUTPUT SETTINGS. Output B should be set to OVER PRESSURE and the over pressure value is usually set for 3-4 PSI. That is the activation point of the ESC function. Feel free to play with it.

Gear Selection:

When doing your full throttle power tuning, gear selection can make a difference. What you may notice is that if you start with full power in 1st and run through all the gears that 1st and 2nd may report a tad lean with the wideband unit. There is not much of a load on the engine in those gears and you will not get a very good reading on the wideband unit in the short time it will be in those gears.

You want things to settle down a bit so you can get good data to work from, and loading the engine so it will not accelerate so fast will provide you better data to work from. I have found that using 3rd gear on autos, and 3rd and 4th gear on manuals will give you the best tuning result. Usually you will not be able to go to full RPM in 4th on manuals because you may reach the point where the vehicle speed limiter engages. If you have a Speed Unlimiter installed, 4th will be the way to go especially on a chassis dyno.

Altitude Changes:

The FTC has a feature that most of these programmable calibrators do not have. It has an internal Manifold Absolute Pressure (MAP) sensor that reads the manifold pressure. This makes the FTC much more expensive to produce, but the extra cost is worth it. As the ambient and weather conditions change you can make different levels of manifold pressure at the same throttle setting.

Keep in mind that the stock ECU and its Mass Air Flow Sensor (MAF) has very powerful altitude correction capability. We are using the MAP sensor to tweak this to our benefit. Using the MAF sensor and tweaking it with a MAP sensor on an engine converted to forced induction is the best way to do it.

The startup maps URD provides are done at sea level. The TRD Supercharger will make around 6-7 PSI of boost at sea level with the stock pulley. If you go up in the mountains the boost produced will be less, much less. At around 5000 feet the supercharger will make only about 3 PSI of boost even if the boost gauge reads 6-7 PSI. The FTC reads absolute pressure calibrated to a true vacuum where the boost gauge reads a differential pressure comparing the manifold pressure to the air pressure outside of it.

What will happen is that the Wide Open Throttle (WOT) part of the fuel map will no longer be at 6-7 PSI, but will drop and drop as you climb higher in altitude. This allows you to tune your truck for best power at any elevation. It will not require a map change as you change altitudes after you finish tuning. So if you live at 5000 feet you can tune your vehicle for that elevation. When you come down to sea level you can tune that part of the map and do that for elevations in

between. Once you have dialed it in for those changes in elevation, it is done and you should never need to retune it.

It is important that if you live at a high elevation you must retune the map for your location and remember the URD "startup" maps are done at sea level. They may be overly rich at higher elevations until your adjust that part of the map.

Temperature Changes:

Temperature changes affect the tune much like altitude changes, but not as drastically. When the ambient temperature is very hot outside the Modified Roots Type Supercharger will draw in that warm air and heat it even more. This will result in a less dense charge and may report as less boost or manifold pressure. The opposite will occur when it when the ambient temperature drops. The supercharger is able to draw in cooler more dense air and it is able to compress it more efficiently and that can result in greater boost or manifold pressure.

You may find that the peak manifold pressure will report differently during various ambient temperature conditions. The tune you did in the hot Summer may NOT be perfect in the cold Winter. The area of the map that the FTC uses at full throttle will be slightly different and this will allow you to precisely tune you vehicle optimum performance under all conditions. You should focus your changes on the full throttle area of the fuel map.

Over the year and season changes you may want to periodically check the tune and make any slight adjustments needed. Once you tune for each season, temperature and altitude changes, you should have your map very dialed in and should not need to retune it from then on as you have covered all the possible conditions the vehicle will operate under.

Ignition Retard Map:

It is important that you understand how the ignition timing works on the Toyota ECUs that URD makes kits for before you start adjusting it. Also we must standardize the terminology used to describe knock or ping. Ping or knock from now on will fit into the following two definitions:

Spark Knock- This is when the fuel/air charge in the combustion chamber is ignited by the spark of the spark plug, but too soon for the conditions. It results in an uneven flame front and you may hear it as a sound that most call pinging. Remember the important thing is the spark of the spark plug starts the process and tuning can address this problem.

Detonation - This is a condition where the fuel/air charge in the combustion chamber is ignited by something other than the spark of the spark plug. This can be extreme heat, way to much boost, and so on. The important thing is that the spark of the spark plug does not ignite it.

If you are having true detonation, you have a serious condition and should expect a catastrophic engine failure in a short time. It is likely going to take more then tuning to address it and will most likely require hardware changes like reducing boost, or lowering compression and so on. This should not be an issue for most of us.

The ECU will always try to run the ignition timing as advanced as possible. It will keep advancing it until it sees some knock from the knock sensors and then pull the timing back until it stops, then it will start advancing it again until it knocks and so on. This process is going on constantly and it is dynamic meaning it is always self-adjusting. The ECU will always try to keep the ignition timing at the knock threshold above 3000 RPM. However, due to the high mechanical noise of the engine and its solid lifters the knock sensors are NOT used below 3000 RPM to adjust the ignition timing. Ignition timing below 3000 RPM is set by the ECU based on an extrapolation of the high RPM ignition timing.

If the high end is running really lean there will be a greater tendency to spark knock and the ECU will use less ignition advance. This results in less ignition timing below 3000 RPM and less tendency to spark knock.

The whole point of the URD Supercharger Performance Upgrade kit is to cure the high RPM lean out problem of the supercharger. By correcting this high RPM lean out the ECU will naturally run the ignition timing more advanced in the upper RPMs and you can make more power. Now because the low RPM timing below 3000 RPM is set based on an extrapolation of high RPM timing the low RPM timing will get more advance and there will be more of a tendency for boost induced spark knock below 3000 RPM. Because the ECU dose not use the knock sensors below 3000 RPM the engine can spark knock like crazy and the ECU will never know it is happening.

We can address this by using map B in the FTC to retard the ignition timing enough below 3000 RPM to suppress the boost induced spark knock. Remember that the fuel map must be tuned first so the high RPM ignition timing will settle in and then you can see what you need to retard below 3000 RPM.
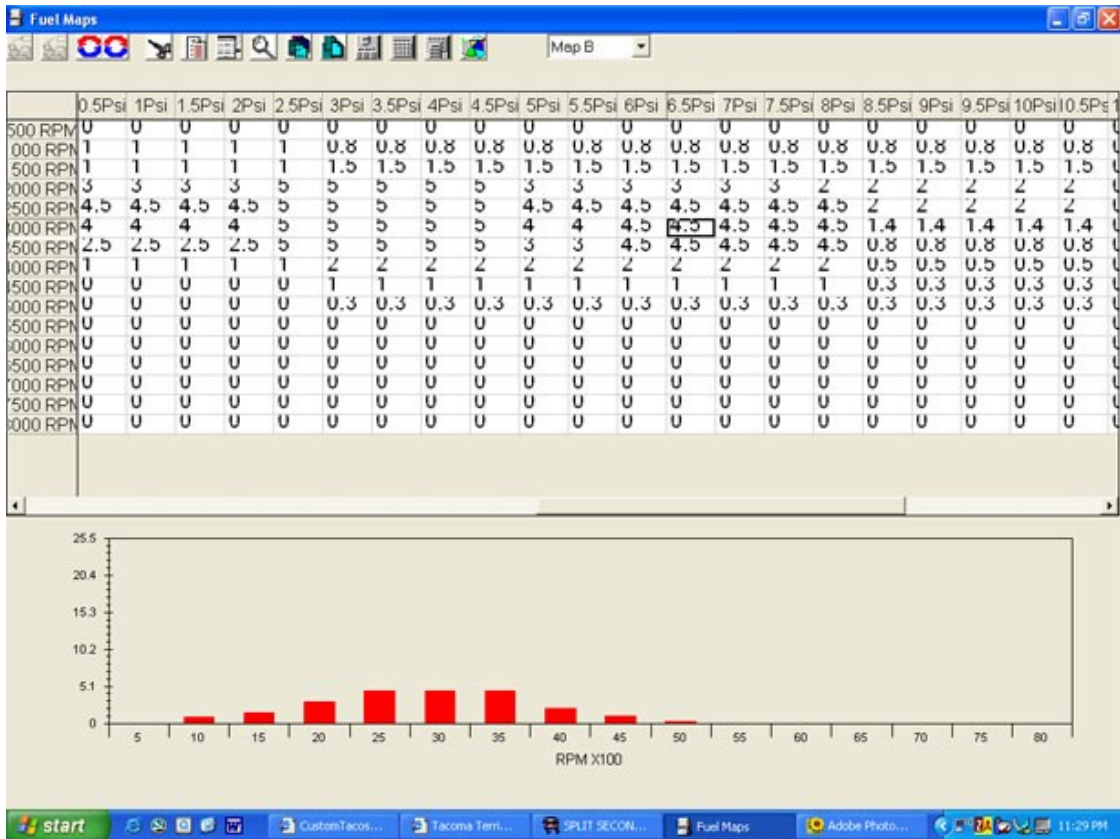
This is a timing retard map from a 2001 Tacoma S-Runner that I tuned. It was the worst spark knocking truck I have ever tuned. Any time it was in boost it was pinging and pinging badly. The URD kit and a good tune cured it, but it did take some work. You can see how the large retard values have been smoothed in with the cells around it.

To tune the ignition retard map is very simple. Connect to the FTC and drive the vehicle. Roll down the window and try to induce spark knock below 3000 RPM. When you hear spark knock, look at the map and see what cell is active and increase the retard in that area of the map. Write the map changes to the FTC and repeat and repeat until you have suppressed all of the boost induced spark knock. Driving up a long hill in top gear at less then 3000 RPM and feeding in increasing throttle is a good way to induce spark knock and show you where you need to make map changes to suppress it.

If you are using water injection, you may find that you will have to retard timing below 3000 RPM before the engine goes into boost. This is from the superior boost induces spark knock suppression in the upper RPM and is common.

You do not want large sudden changes in the retard values from cell to cell. Say if you find that in one cell you need 5 degrees of retard you will want to smooth in the cells around it.

In regions of the load map where the ECU is dynamically controlling timing advance, you can see knock retard on the scan tool. Sudden drops in the timing advance that repeats indicate that knock retard is happening. Add retard to map B in areas of the timing map where that occurs until the ECU is no longer going into knock retard.