Subaru Advanced Tuning Guide

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Disabling Rear O2 Sensor-based Fuel Trims on 2.5L Turbo Vehicles

Date: 2/14/2012

Until recently, 2.5L turbo Subarus required the rear O2 sensor to remain in-place and functioning even when utilizing the vehicle under offroad applications. This is because the sensor was used for auxiliary short-term and long-term fuel trimming, which can be observed under “A/F Correction #3” and “A/F Learning #3”. It was also used to make minor corrections to the currently-targeted Closed Loop Air/Fuel Ratio, causing intermittent operation far below stoichiometric under cruising conditions. Without an accurate reading, under certain circumstances these trims or CL Target correction can vary wildly and cause highly unpredictable richening or leaning of the current air/fuel ratio. Following our formal 2.5L Speed Density release, it is now possible to set the correction ranges allowed for each of these. By zeroing the maximum and minimum corrections (to both trims and CL Target) allowed, fuel trims based on the Rear O2 Sensor will no longer be active. NOTE: if the sensor is removed entirely, the associated DTC's must also be disabled. These tables are currently only available when using the “Speed Density” ECU option; these tables will be added to the classic/standard ECU option at a later time.
Properly Raising Idle Speeds on 2.5L Turbo Vehicles

Date: 7/15/2011

When raising the target idle speed tables on 2.5L DBW vehicles, it is helpful to also adjust other aspects of the tune to ensure predictable operation and smooth drivability.

Overrun Fueling Resume

One of these is known as the “Overrun Fueling Resume RPM Thresholds” table and is described as such: “When RPM is less than or equal to this table's value, the potential for resuming fueling during overrun fuel cut is increased (dependent on other factors). When RPM is greater than this table's value, this table has no effect.” From the factory, this table is set with higher values than the idle speed tables to ensure that the engine smoothly returns to idle from after overrun (decal) fuel cutoff:

- Stock 2004 STi Overrun Fueling Resume RPM Thresholds:

![Overrun Fueling Resume RPM Thresholds diagram]

- Stock 2004 STi Idle Speeds Target A (B and C are similar):
If higher idle speeds are desired, it is suggested to raise both of these tables by the same value. For example, if an idle speed of 900 RPM is desired, here is an example of appropriately adjusted tables:

- Raised 2004 STi Overrun Fueling Resume RPM Thresholds:

![Image of Overrun Fueling Resume RPM Thresholds]

- Raised 2004 STi Idle Speed Targets A (B and C should be adjusted in the same fashion):

![Image of Idle Speed Targets A]

As these are “base” tables, please be sure to save and reflash the changes to apply them to the vehicle.

**A/F Learning Range Breakpoints**

Another aspect to consider is the A/F Learning Range A/B/C/D breakpoints. The “A” Range is generally intended to apply during normal idle speeds once the engine has reached full operating temperatures. In other words, the MAF g/s values observed during normal idling conditions (~3.25 g/s on a stock vehicle with stock intake, for reference) are intended to fall within the thresholds for the A/F Learning A range. In the example vehicle (2004 STi), this is for MAF g/s values below 5.60 g/s, as seen here:
Depending on the MAF calibration, intake hardware, idle speed, turbocharger, camshaft profile, etc., the MAF g/s values observed while idling may be near or above the factory threshold between the A and B ranges. For example, if the vehicle is observed to idle at approximately 6.00 MAF g/s, you can properly adjust for this by raising the A threshold. Raising the B threshold as well will ensure that range can also be used effectively:

While the learned ranges can be refreshed while Live Connected to the ECU, the threshold values are not realtime adjustable. Please be sure to save the updated map and reflasch the vehicle to apply the changes.
Disabling Long-Term Fuel Trims under Open Loop or “WOT” Operation

Date: 7/16/2011

Updated: 2/14/2012

From the factory, all Subaru ECUs use four distinct learning ranges for learned long-term fuel trims (“LTFT”). These are known as “AF Learning A/B/C/D” and can be logged or viewed in realtime while Live Connected to the ECU. The three break-points given in the “A/F Learning #1” table will determine the thresholds between each range (A-B, B-C, C-D). The min for range A and max for range D are determined by “A/F Learning Modify Airflow Limit (Min)/(Max)” tables, respectively. Keep in mind that this is only the cap for when learning is active, the actual learned value will be applied at all times while above the C-D threshold value.

Thus, we can disable learning in the D range by setting the “Max” table to just below the C-D threshold. It may be desirable to disable learning in the D range to prevent from learned fuel trims under cruising conditions from causing undesirable leaning or richening of the air-fuel ratio during open loop operation. This will still allow for the A, B and C ranges to be learned and used under various cruising conditions based on fueling errors between those breakpoints. Slightly extending the C-D threshold will ensure the C range appropriately covers cruising conditions now that the D range is no longer in use. Please see below for an example of modified A/F Learning #1 ranges with a disabled D range:
Raising the Rev Limiter for 2.5L Vehicles

Date: 7/15/2011

From the factory, many of the 2.5L DBW implement a “soft” throttle-based rev limiter in addition to the normal fuel-cut based rev limiter. As such, achieving higher engine speeds than factory often
requires also calibrating the DBW system to compensate for the new desired rev limiter. Here is how the throttle-based limiter function is achieved on the stock 2004 STi:

Requested Torque is lowered significantly as the engine approaches 7000 RPM, which will effectively disable the engine from accelerating further by closing the throttle plate. For modified engines that can safely sustain higher rotational speeds, the axis values can be edited to allow for higher speeds while retaining the soft limiter function. For example, if a 7500 RPM limiter is desired:
Be sure to also adjust the fuel-based rev limiter as desired (Miscellaneous Limiters, Rev Limit (Fuel Cut) Primary). For vehicles that utilize multiple Requested Torque tables, be sure to raise all tables as desired.

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**Raising the Load Limit on 2.5L Vehicles**

Date: 8/4/2011

Updated: 2/13/2012

Many of today’s modified 2.5L Subarus with large turbochargers are able to meet or exceed the factory 4.0 g/s load limit. With the AccessTUNER software suite, raising this limiter to facilitate proper tuning is very simple. Earlier vehicles use a single table: under the “Miscellaneous Limiter” folder, raise the limit in the "Load Limit (Max) Primary" table as desired. For later vehicles (09-11 FXT, 10-11 LGT, 08-11 STI, 08 WRX MT/AT, 09 SGT, 09-11 WRX) it is also necessary to modify the "Load Limit (Max) Secondary Compensation (Barometric)" or "...(Intake Temp)" tables. If you change either of these to +100%, it will double the load limit present in the "Load Limit (Max) Secondary" table (ex. 4.0 g/rev = 8.0 g/rev, or 16.0 g/rev if both are set to 100%).
Scaling for Aftermarket MAP Sensors

Date: 6/26/2011

In order to utilize the factory ECU’s boost control and boost-limit/fuel-cut features above 2.5 bar (~22psi of boost), the factory MAP sensor must be upgraded. Popular choices are the AEM 3.5 bar and OmniPower 4 bar sensors. While often used on other applications, we do not generally recommend the GM 3 bar sensor due to inconsistency between manufacturing batches. Like many standalones, the factory ECU’s calibration data for a linear MAP sensor is based on a “multiplier” and “offset”, which is based on the common algebraic equation for a straight line, \( y = (m \times x) + b \), where \( m \) is the multiplier (slope) and \( b \) is the offset (y-axis intercept). For example, if the sensor manufacturer states the sensor will read 50 PSI at 4.5v and 0 PSI at .5v, first calculate the slope: \((0-50) / (0.5-4.5) = 12.5\). Then, calculate the offset: \(50 = (12.5 \times 4.5) + b; b = -6.25\). For this sensor, the appropriate calibration values are a multiplier of 12.5psi and an offset of -6.25psi. You can double-check the accuracy of your calibration with the new sensor by comparing the “Barometric Pressure” and “Manifold Abs. Pressure” monitors with the key on and engine not running.

Targeting Richer Air-Fuel Ratios during Closed Loop Operation

Date: 8/5/2011

Updated: 2/14/2012

Many cars that are equipped with large performance-oriented camshafts will demonstrate smoother operation and improved drivability from slightly richer than stoichiometric AFR under light cruising conditions to promote combustion and prevent lean misfiring. The tables that control the AFR (lambda) value that is targeted during Closed Loop operations are now available to be manipulated; the value actually being targeted while running can also be logged using the “Closed Loop Fueling Target” monitor. “Commanded Fuel Final” displayed the targeted AFR value under open loop operation.

The closed loop fueling target is controlled by the “Closed Loop Fueling Target Compensation (Load)” tables (some vehicles will have A/B tables; both should be modified). As per the table guide: “This is the compensation to the closed loop fueling target based on calculated load and RPM. This table's value is added to the target, along with other compensations, to determine the final target. Note: Positive compensations (i.e. leaner impact) in this table will potentially force open loop fueling during closed loop.” This is an “adder” table that contains negative values, which has the net result of feature a richer AFR
(numbers smaller than 14.7). For instance, setting a value of -0.4 will result in a targeted AFR of 14.3 
(14.7 + (-0.4)) = 14.3. Note: If the current targeted Closed Loop value is richer than the value set in the 
“Open Primary Open Loop Fueling Min. Activation”, Open Loop operation may result.
Inconsistencies in Realtime Table Selection

Date: 6/26/2011
Update: 2/14/2012

Following our recent software and table definitions update, you may have noticed that some tables marked as “Cruise” are available under the Realtime tables list. The table available in Realtime is the same as before; recent ECU discovery has facilitated better understanding of the logic and conditions that control when to switch between the various ignition timing tables (we now know exactly which are “Cruise” vs “Accel” tables). Changing the realtime tables available would have created incompatibilities with existing mapping, thus the table selection was left unchanged. Please be sure to check or tune all “Accel” and “Cruise” tables as desired, regardless of the selection available in Realtime. We are evaluating potential solutions for exchanging the “Accel” and “Cruise” tables where these situations exist to ensure consistencies. Note: These inconsistencies have been addressed within the newly-released “Speed Density” ECU.

Tuning Open Loop Fueling on the 2008-2011 STi

Date: 5/25/2011
Updated: 2/13/2012

Thanks to recent ECU discovery, we have found that the 2008-2011 STI actually uses two Primary Open Loop Fueling tables. These tables are named “Primary Open Loop Fueling (Dyn. Adv. Adder B High)” and “Primary Open Loop Fueling (Dyn. Adv. Adder B Low)”. These are found in the “Fuel Tables”, “Open Loop (Primary)” – please see below. Depending on the year of the vehicle, one (but only one) of these two tables will be Realtime tunable (as indicated by the red “R”). Complex logic determines a sliding scale to apply between these two tables and it cannot be guaranteed which of the two will more heavily affect the current fuel target at any given time. As such, when custom tuning, we recommend setting these two tables to the same values to ensure consistent fueling and that any changes made will immediately be observed. This can be easily done using the copy and paste functionality (Ctrl-C and Ctrl-V, respectively) within AccessTUNER then reflashing the new map. UPDATE: This has been “fixed” within our definitions for the 2012 STI and for all 2008-2012 STI “Speed Density” ECUs.
Tuning Dynamic Advance on the 2004-2011 STi

Date: 5/25/2011

Recent ECU discovery has exposed new logic within all current years of STi ECUs that can cause potentially unstable ignition timing or undesired increases to overall current timing being applied. Depending on the year, the STi has one or more “Dynamic Advance Max. Adder” tables as well as one or more “Dynamic Advance Max. Primary” tables.

The logic used for determining when the “Dynamic Advance Max. Adder ___” tables are active is not straightforward, which means that values from these tables can be arbitrarily added to total current timing at undesirable times. As such, it is recommended that all “Dynamic Advance Max. Adder ___” tables should not be populated with values in order ensure consistent timing. This can be easily done by selecting the entire table(s), then pressing “E” and entering the number “0”.

The “Dynamic Advance Max. Primary ___” tables will always be applied, but the conditions to determine which table is active are not the same across years. The 2007-2011 STi vary with the Accel/Cruise switch, which is a known set of thresholds such as Requested Torque and RPM; the 2004-2006 STi vary with a more complex and ambiguous set of thresholds based on historical knock.
As such, setting all “Dynamic Advance Max. Primary ___” tables to the same values will ensure a consistent Dynamic Advance value is applied under all conditions.

2004-2006 STi:

![2004-2006 STi AccessTuner Image]

2007+ STi:

![2007+ STi AccessTuner Image]
General Subaru ECU Formulas

Total Ignition Timing (all 2.5L): Primary Ignition + (Dynamic Advance * DAM) + Feedback Knock Correction + Fine Knock Learning + Compensations

Total Ignition Timing (only 2.0L): Primary Ignition + (Dynamic Advance * (DAM/16)) + Feedback Knock Correction + Fine Knock Learning + Compensations

Load: (MAFгр / RPM) * 60

Aftermarket Injector Scaling: (Factory Injector Size in CC / New Injector Size in CC) * Factory “Fuel Injector Scale”

Common Subaru Acronyms

DBW = “Drive By Wire”. Electronically-actuated throttle plate; present on all factory 2.5L turbo USDM vehicles.

DBC = “Drive By Cable”. Cable-actuated throttle plate; present on all factory 2.0L turbo USDM WRX.