# Deceleration

## or "You Better Slow Down!" (a quote from my ex-wife)

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*The information contained in this article is based on the 1986/87 Buick turbo V6 ECM and the factory chip (labeled ACXA 0942). Memory addresses are shown as well as the formulas to calculate data values for those who are interested.*

**Introduction:**

The real excitement with these cars is the awesome acceleration however, when we let up on the gas pedal the ECM checks for conditions that reduce the fuel in one of two deceleration fuel modes. The main purpose: … emissions. Upon deceleration, a lean fuel mixture is required to reduce emission of hydrocarbons (H) and carbon monoxide (CO). To accomplish this, the fuel is either reduced by the Deceleration Enleanment (DE) portion of the program or it is shut off completely during a fuel mode called Deceleration Fuel Cut Off (DFCO).

**Deceleration Enleanment (DE):**

When the program detects a sudden drop in throttle position and engine load, it reduces the fuel while continuing to monitor engine load and vehicle speed. Engine load (referred to as LV8) is a calculated value derived from engine RPM and airflow. Engine load changes are detected by subtracting the current LV8 value from a *filtered LV8* value. The filtered value is a sample or percentage of the LV8 that is taken at a rate slower than that used to calculate the current LV8. The current LV8 is calculated every 12.5ms. One half ($45C) of the current LV8 is used as the sample and the filtered version is updated every 0.3 seconds ($45B). This process smoothes the changes and eliminates the affect of short duration changes.

[$3A5A] For the purpose of DE, the program subtracts the current LV8 ($23) from 2x filtered LV8 ($9D x 2) to determine if the load has decreased. If it has, the vehicle speed ($26) is compared to the Min Speed for DE of 12 MPH ($456). [$3A81] Next, the amount of engine load decrease is compared to the Min LV8 Delta for DE of 24 ($44E). Finally the Throttle Position Sensor (TPS) is checked to determine if the gas pedal has moved enough to enable DE.

When checking throttle position, the ECM normally uses the output from the TPS as is but for DE it filters the reading in a manner similar to how LV8 is filtered. [$38FC] The current TPS% is multiplied with a DE coefficient and with the previous DE filtered TPS%. The coefficient for DE is 0.0625 ($461). This means 94% of each current TPS reading is multiplied with the last DE filtered TPS% to produce the new DE filtered value. Then the current (non-filtered) TPS% ($36) is subtracted from the filtered TPS% ($9F) to determine if the throttle position has decreased enough for DE. The decrease in TPS% needed for DE is only 0.7813 or 0.8% ($44C).

Summary: To enter Decel Enleanment,

- the vehicle speed must be > 12 MPH, and
- the LV8 Delta (2x filtered LV8 minus current LV8) must be at least 24, and
- the TPS Delta (filtered TPS minus current TPS) must be at least 1% (rounded from 0.8%).

As stated earlier, the purpose of DE is to produce a lean fuel mixture by reducing the amount of fuel going to the engine. [$3EFA] After the program calculates the injector pulse-width based on present (non-DE) conditions, the pw is reduced by a percentage taken from the DE Injector PW Scaler table ($451). The factory table values reduce the fuel by 10% to 25%. The state of the transmission Torque Converter Clutch solenoid (locked or not locked) and the number of engine revolutions since DE started determine the reduction percentage.

| Deceleration Enleanment Injector PW Scaler ($451) | | | | | |
|---|---|---|---|---|---|
| **TCC** | **Reference Cnt** | **(hex)** | **(dec)** | **Mult** | **Reduction** |
| **Not Locked** | **1 - 8**<br>**9 - 100** | CD<br>E6 | 205<br>230 | 0.8008<br>0.8984 | 20%<br>10% |
| **Locked** | **1 - 8**<br>**9 - 100** | C0<br>DA | 192<br>218 | 0.75<br>0.8516 | 25%<br>15% |

**BPW Scaler for DE (0 – .996)**
- table value not stored

Table provides reduction multiplier for injector pulse-width during DE.
Index is Ref Pulse Count and TCC state
Table value formula:
`DE_Scaler = N/256`

The ECM constantly monitors the pulses from the Crankshaft sensor but during DE the program uses these pulses to increment a Reference Counter ($A3). [$E218] This counter is "capped" at $100_{10}$ ($450) then it is put back to 00 and it counts up again. The table uses a Reference count of $9_{10}$ ($44F) to separate the fuel reduction percentages with the fuel reduction greater during the first few engine revolutions after entering DE. There is a slight increase in fuel reduction if the transmission TCC is locked, but I'm not sure why.

<u>What conditions turn off DE</u>?
[$3A5A] DE is disabled when the LV8 Delta (filtered LV8 minus current LV8) shows an increase of more than 02 ($44D) or if the vehicle speed drops below 12 MPH ($456). Also each time the Reference Count reaches 100, the program makes the "DE enable" check and if either the LV8 or TPS delta values changed enough to no longer meet the enable requirement, DE is turned off.

<u>How does DE fuel reduction affect BLM "learning"</u>?
[$3D44] While DE is causing fuel to be reduced, the normal "learning" process continues with one exception. Normally when the mixture is lean, the Integrator is incremented to cause more fuel to be injected during the next cycle. When Decel Enleanment is on, a lean mixture with the Integrator > 128 *(indicating fuel is being added)*, will cause the Integrator to be reset to 128. This stops the addition of fuel and stops the learning process. If at the start of DE, the mixture is lean but the Integrator is < 128 *(indicating fuel is being subtracted)*, the normal learning process is allowed to continue. The only other possibility is that at the time DE starts, the mixture is rich. The normal learning process will be allowed to continue because it will cause fuel to be subtracted until the mixture is no longer rich.

[$3DEB] It is possible for the car to be decelerating but not enough to enable the DE fuel mode. The ECM checks for this because the normal closed loop fuel adjustment might be adding fuel at this point and the program wants the deceleration fuel mixture to be lean. To detect deceleration when DE is not enabled, the program looks for the LV8 to be at or below 38 ($420) when the RPM is above 1000 ($421). Normally when the LV8 is below 38, the RPM will be *below* 1000, like during idle. At the start of deceleration the LV8 drops quickly but it takes longer for the RPM to go down. The program refers to this condition as "C/L Decel Enleanment" but it is not a fuel mode like DE and DFCO. It does not cause a reduction of the injector pw but it will affect the normal "learning" process as described in the previous paragraph.

**<u>Deceleration Fuel Cut Off (DFCO)</u>:**
Where the conditions to enable DE are based on change, the conditions for DFCO enable are fixed values. The DFCO fuel mode is entered after moderate to heavy acceleration then releasing the accelerator. There is a good possibility that the program will enable DE prior to DFCO and as the deceleration continues, the conditions may or may not cause DE to turn off by itself, however when DFCO starts, DE is disabled. [$3A71]

[$FD3C] The conditions necessary to enable DFCO are shown below in the order they are checked.
- Coolant temperature has to be 122 ºF ($445) or above, and
- Transmission not in Park/Neutral, and
- TPS <= 2% ($444) with no TPS Error Code (Malf 21 / 22), and
- LV8 <= 34 ($440) with no MAF Error Code (Malf 33 / 34), and
- RPM > 1200 ($43E)

Note: DFCO can still be enabled if there is a TPS error, the TPS is just not checked.
DFCO can still be enabled if there is a MAF error, the LV8 is just not checked.

If all these conditions are met, the ECM starts a ½ second ($443) delay timer ($94). During the delay, the ECM continues to check for the above conditions and if any of them are no longer met, the delay counter is put back to its starting number and there is no DFCO.

[$FD85] After the ½ second delay, another timer ($3D) is checked to see if it has been at least 10 seconds ($44A) since the last time DFCO was enabled. This is the minimum time between consecutive DFCOs. If this timer = 0, the DFCO enabled flag ($0B bit1) is set and the DFCO Stall Saver flag ($07 b4) is cleared. (DFCO Stall Saver is explained in a moment.)

<u>What happens during DFCO</u>?
As the name indicates, fuel is *cutoff* during this mode. [$3B3C] The first thing DFCO does is make the LV8 Delta AE injector pulse-width ($95) = 00. There is no check to see if this form of Acceleration Enrichment is actually being applied.

Then the program continues with normal processing, including the calculation for injector pulse-width based on current (non DFCO) conditions. [$3F4C] Just before the fuel signal is sent to the injectors, DFCO causes the injector pw ($83) to be changed to zero, along with the TPS AE injector pw ($98).

<u>What about BLM "learning" during DFCO</u>?
The closed loop (C/L) portion of the program monitors the Oxygen sensor output and adjusts the Integrator and Block Learn Memory (BLM) values to keep the AFR at 14.7:1. When DFCO shuts off the fuel the Oxygen sensor reports a lean fuel mixture. [$3D2D] To prevent "learning" during DFCO, the Integrator is held to the value of 128. The BLM value won't change as long as the Integrator is 128.

[$F179] DFCO also turns off the Charcoal Canister Purge (CCP) solenoid by setting the duty cycle ($CD) to 00.

<u>What stops DFCO</u>?
[$FD3C] The conditions that turn off DFCO are:

- TPS > 2% ($444) with no TPS Error Code (Malf 21 / 22), or
- RPM decrease of 100 or more ($442) in last 50msec, or
- LV8 > 52 ($441) with no MAF Error Code (Malf 33 / 34), or
- RPM < 800 ($43F)

Note: DFCO can still be disabled if there is a TPS error, the TPS is just not checked.
DFCO can still be disabled if there is a MAF error, the LV8 is just not checked.

Pushing the gas pedal down just a little (> 2%) will not only turn off DFCO, but will reset the DFCO Re-enable Counter ($3D). This allows the next DFCO to occur at any time and not have to wait 10 seconds. The LV8 rising above 52 is an indication the car is speeding up. Finally, if DFCO is on because you are braking, it shuts off if the RPM drops 100 or more in 50ms or it goes below 800.

**<u>"DFCO Stall Saver":</u>**
A portion of the program is devoted to a function called DFCO Stall Saver. As the name implies, the engineers were concerned that the fuel cutoff might cause the engine to stall. In the '86/87 program it does little or nothing, but here's how it works: When DFCO starts, a timer ($3D) is set to 10 seconds which represents the minimum time between consecutive DFCOs. [$3A24] When DFCO is turned off, the next 10 seconds are used to monitor the RPM. If it drops below 800 RPM ($43F) or if it drops too fast, which is defined as 100 ($442) or more RPM within a 50ms period, the ECM sets a flag called "DFCO Stall Saver" ($07 bit 4).

[$3AE5] One of the functions originally intended for the DFCO Stall Saver condition was to add something to the fuel being supplied if the ECM turns on Acceleration Enrichment (AE) during the Stall Saver period. The TPS AE fuel injector pulse-width ($98) would be affected by this, however the amount added ($447) is *zero* for the '86/87 turbo V6. The program also has provision for this fuel to be added some number of times ($40) or passes through the code, but this value ($449) is also *zero*. [$E857] The only thing the program does with the DFCO Stall Saver is set the Idle Air Control (IAC) valve to a fixed position, rather than adjusting it based on actual TPS as it normally does. The "DFCO Stall Saver" IAC position is equivalent to a TPS of 1% ($446).

"DFCO Stall Saver" is only active for one pass through the program. This is because the number that determines the IAC position also determines how many code passes ($446). [$3A51] This number starts at 03 and is immediately changed to 01, then stored ($3F). The portion of the program that sets the IAC position also decrements this number, so the first pass through the program reduces the number to zero. As long as this number is zero, the DFCO Stall Saver flag has no affect (even though the flag is still on). The control flag isn't actually turned off until the next time DFCO is enabled.

**DFCO Program "Bug" and Fix:**

The DFCO portion of the program stored in ROM contains a "bug" and when it was discovered, the fix was applied to the PROM portion so the previously burned ROM chips could still be used. The control flag for DFCO is $0B bit 1 but the program in ROM [$FD89] *incorrectly* uses $08 bit 1 to enable/disable DFCO.

[$38CA]The fix for this bug makes $08 bit 1 the same as $0B bit 1 prior to the program in ROM being executed. When this portion of the program is finished, the ECM jumps back to the PROM program. Here, the control flag is put back where it should be ($0B bit 1 is made to equal $08 bit 1). If DFCO is enabled, the entry point in the PROM program is $3A24. If DFCO is not enabled, the entry point is $3B3C.

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