OBDII Primer – Short Term & Long Term Fuel Trims

OBDII, or On-Board Diagnostics 2nd Generation, has to do with two things. One, to consistently control the engine fueling to maintain a stoichiometric [or 14.7 to 1] air fuel ratio; and two, to monitor things and alert when it can't do that.

Maintaining stoichiometry has everything to do with keeping emissions as low as possible, and keeping performance optimal. The engineers have done their thing and they know how much air and fuel a given engine will consume at a given temperature, RPM, throttle opening and load. Believe me, that's the science of it, and they know what they are doing. So, if they know how much fuel it will need, they can program it to deliver that amount of fuel. Now, delivering that correct amount of fuel is dependant on everything else being correct, meaning no vacuum leaks, no fuel vapors or raw fuel etc. getting in there to upset the apple cart. If all is copasetic, all the air entering the engine is going through the Mass Air Flow sensor to be measured. That's how the ECM knows how much air is there to put fuel with, hence, air/fuel ratio. This is where fuel trims come in. If the air is measured correctly, the ECM fuels according to its programming, and it is said to be "on program". If the engineers have done their programming correctly, the fuel trims will be something like Figure 1, bouncing right around 0%, plus or minus a small amount. In a perfect world, that is what we want. Now let's upset a couple of apple carts!

Note: All the illustrations in this primer were taken from a 2009 XF 4.2L idling at full operating temperature.

All engines have some sort of crankcase breather system, which keep crankcase gases and pressure at bay. The breather system has the PCV Valve that most people are familiar with, or some other similar device, to pass these gases into the induction system and through the engine to be burned. I'm going to use that breather system for illustration purposes here.

As I said, in Figure 1 all is well. Now I'm going to introduce what is basically a small indirect vacuum leak, so we can see how the ECM responds. I simply pulled the engine oil dipstick up off its seat by about an inch. If you've ever noticed, most dipsticks have a small "O" Ring seal on them that seals the tube when it is fully inserted. Unseating the dipstick made a small opening that allowed the breather system to draw outside air into the crankcase. This means there is now air in the mix that the engineers did not count on. Figure 2 shows the ECM response to this little bit of unmeasured air. The Short Term fuel trim goes positive by 12-14%. A positive trim value means the ECM is ADDING fuel at 12-14% above the programmed rate. A negative trim would mean the ECM is SUBTRACTING fuel from the programmed rate. The ECM made the Short Term trim change because the extra air was measured by the oxygen sensors. If it sees extra oxygen, it has to add fuel to burn that extra oxygen. Short Term trim is just that, short term. If the ECM sees it has to keep adding fuel for a period of time, it basically assumes that is the new "normal" and increments the Long Term trim by that amount. Once that happens, the Short Term trim is again bouncing around 0%. On to Figure 3.

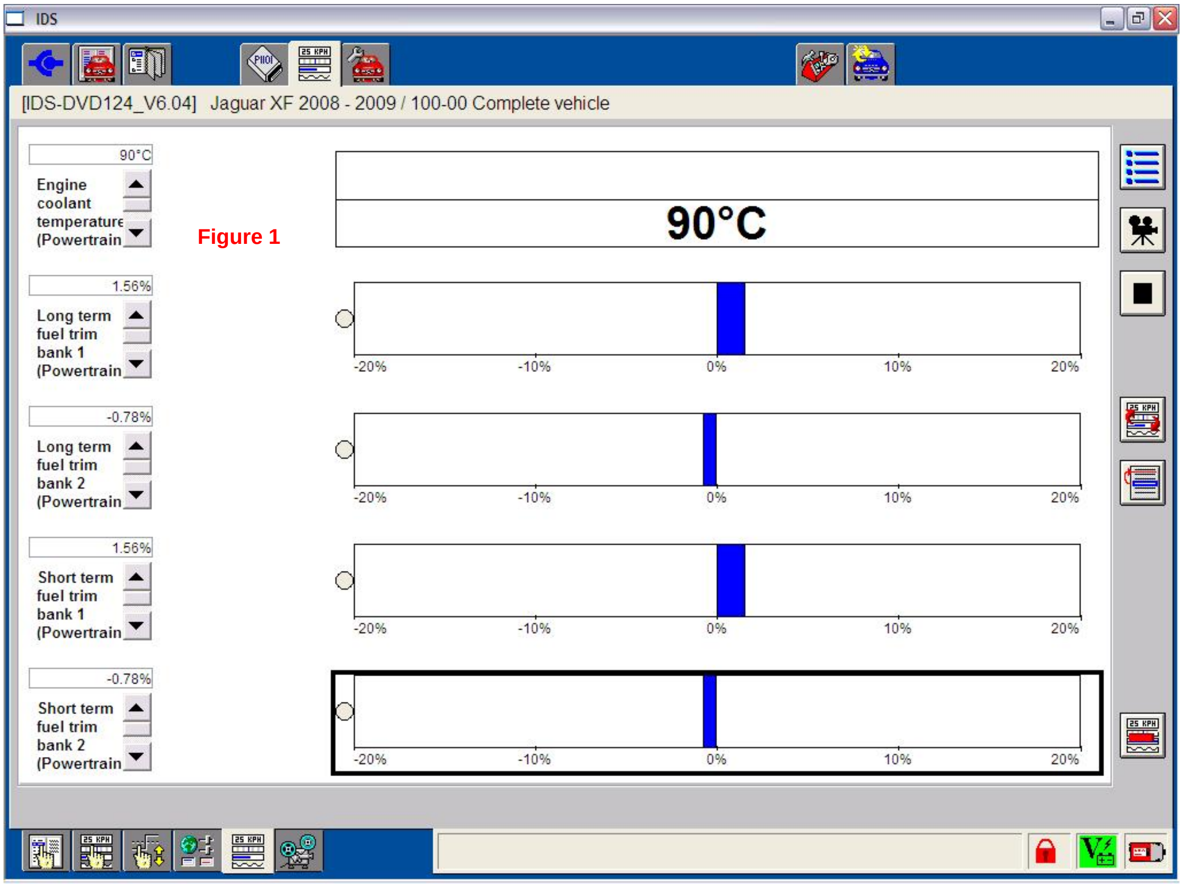


Figure 1

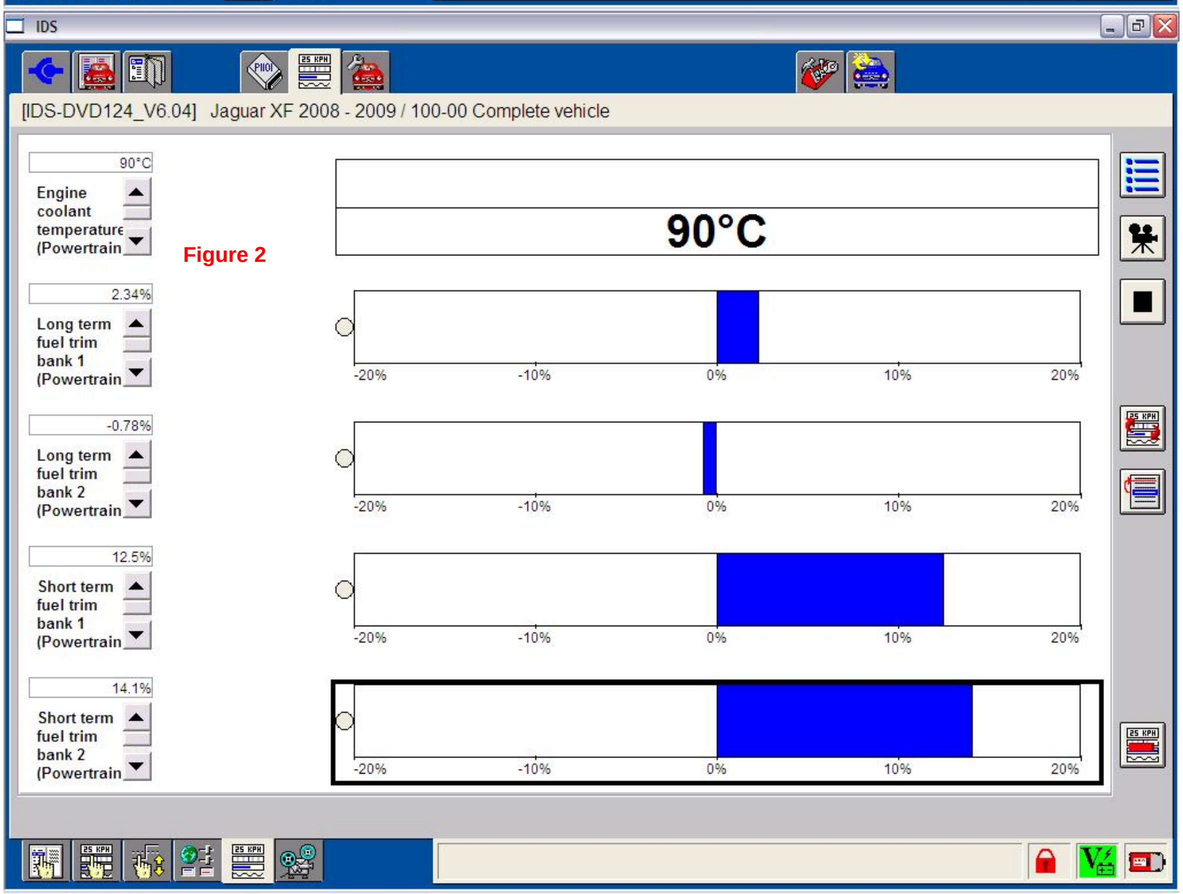
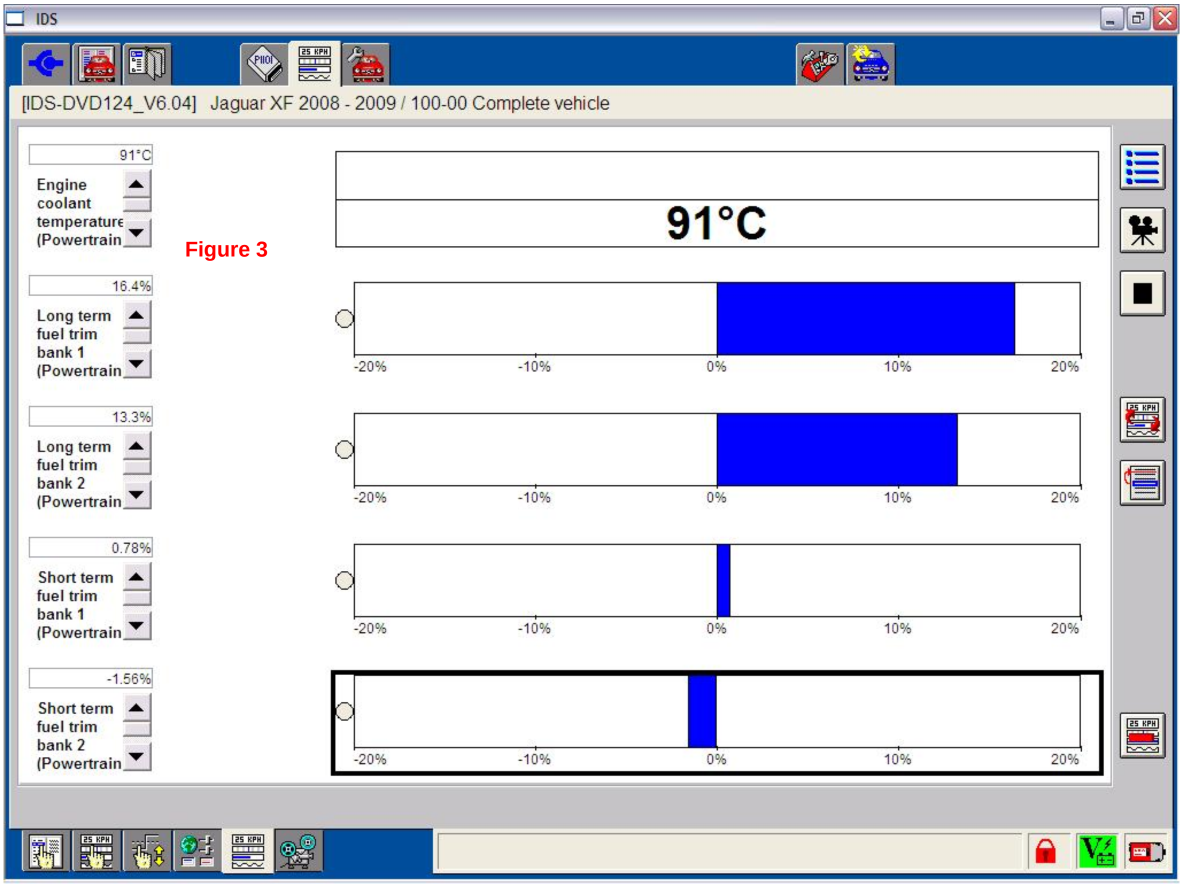


Figure 2

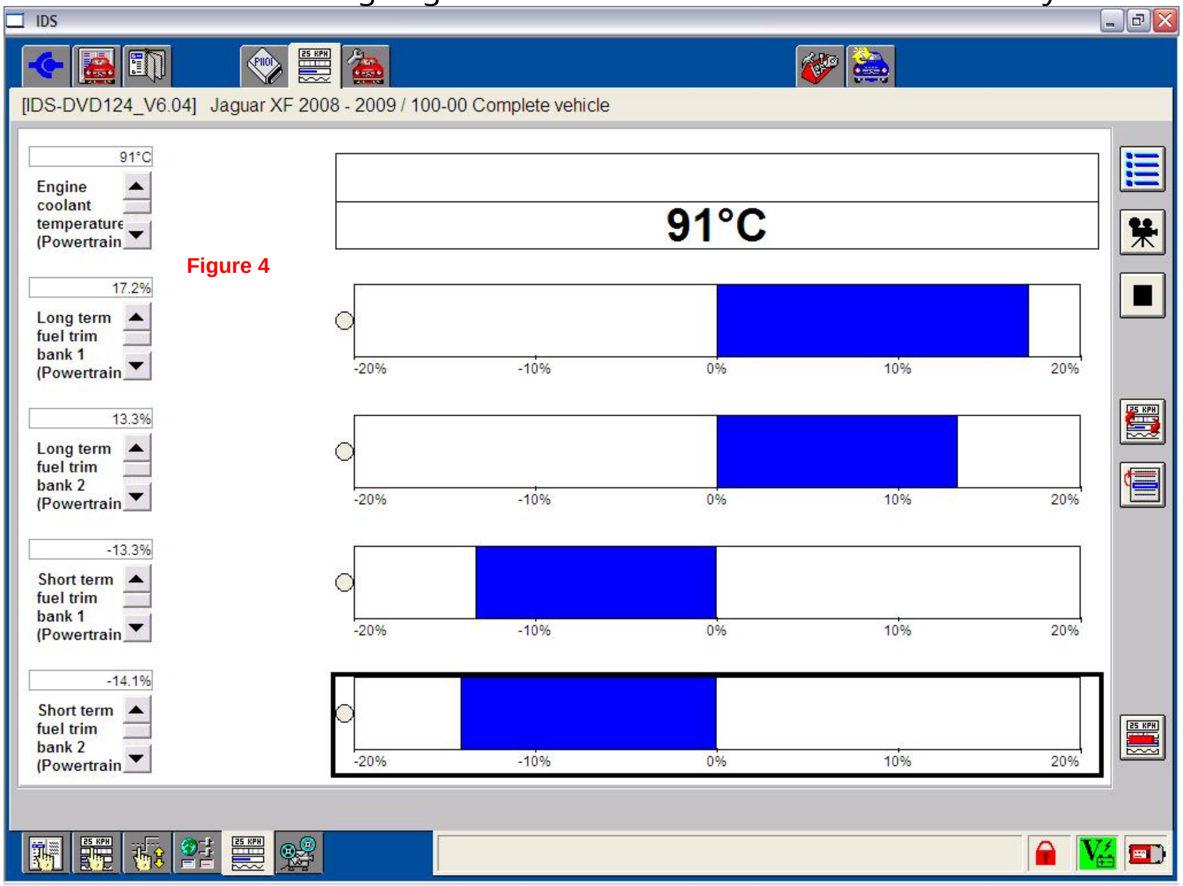
Figure 3 is taken at about six minutes after the introduction of the air leak. Enough time for the ECM to increment the Long Term trim, and allow the Short Term to settle back to a neutral value. If this car runs long enough with Long Term trim values this high, the ECM will set lean faults such as P0171 and P0174. High positive Long Term trims equal a lean running engine. Were these negative Long Term trims, rich faults P0172 and P0175 would result. Bingo, there goes the "Check Engine" light, the signal that the car may not be meeting emission requirements.



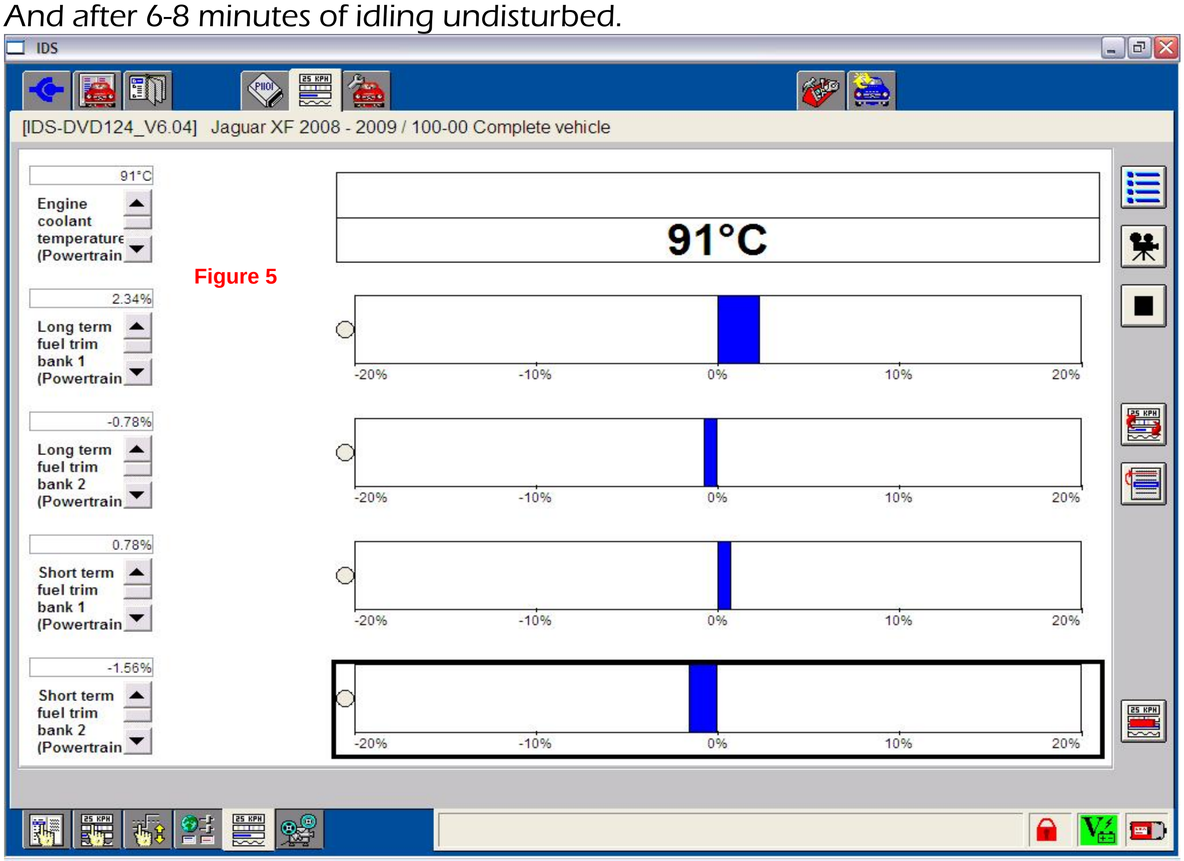
Now that we've seen things go one way, we can also make them go the other. Next I just pushed the dipstick back down and seated it, and we see what happened in Figure 4 on the next page. After plugging the little hole in the crankcase, the oxygen sensors detect the loss of that un-metered air, and the ECM responds by taking the Short Term trims negative to compensate. After another 6 or 8 minute wait, we come to Figure 5, everything is again bouncing back and forth across 0%.

At this point I should point out that now, it's not too much of a stretch to see how other things can cause the same result. A cam cover gasket leak, or a damaged seal on an oil fill cap, could also allow unmetered air to enter the engine. Absolutely anything that goes awry will in some way impact fuel trims, and that we can monitor.

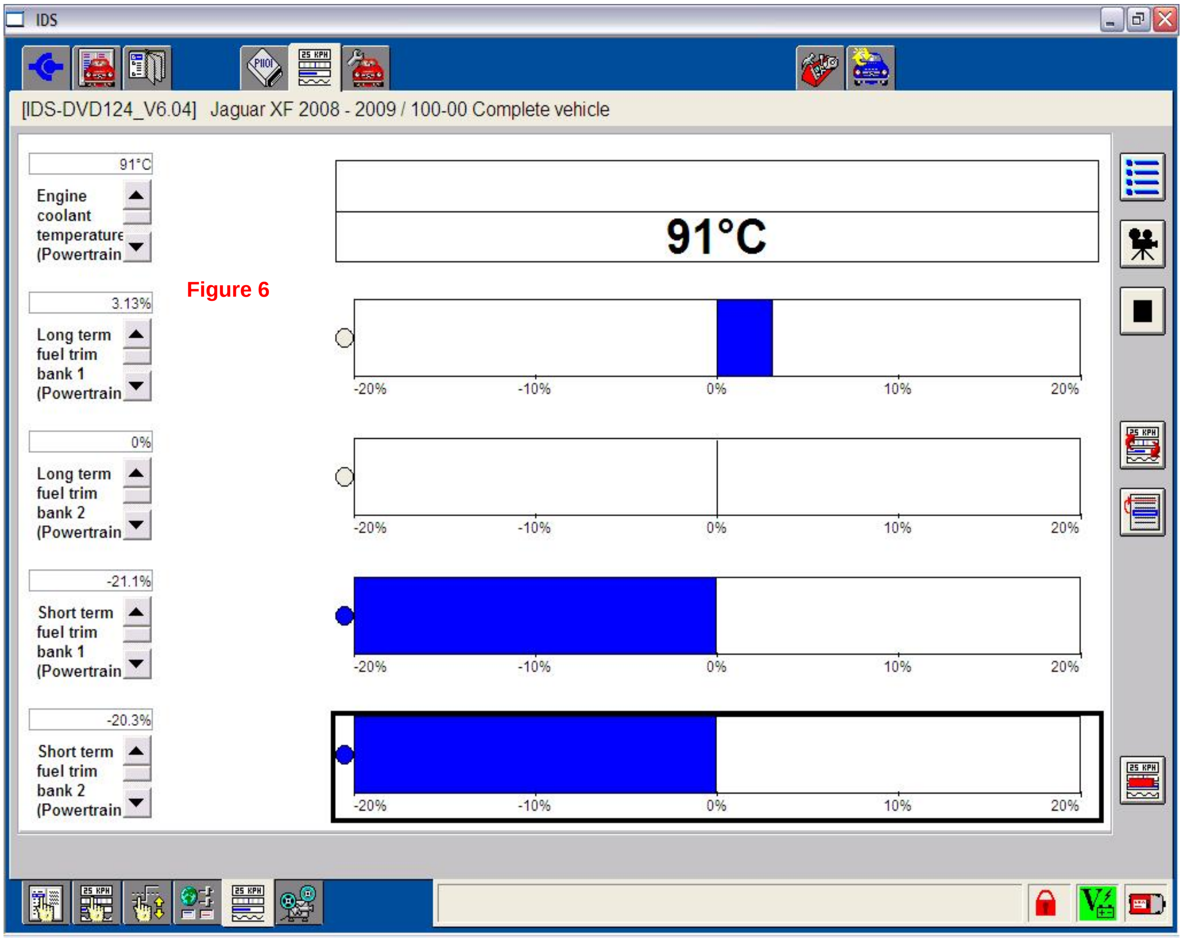
Here are those fuel trims going backwards after the “fault” was taken away.



And after 6-8 minutes of idling undisturbed.



Now, just for grins, I decided to make it work the other way, toward the negative end of the scale. I used a volatile cleaner in a spray can, [in this case a brake cleaner] and put a little spritz into the air inlet snorkel. Just a split second burst produced this, a big effect on the Short Term trim.

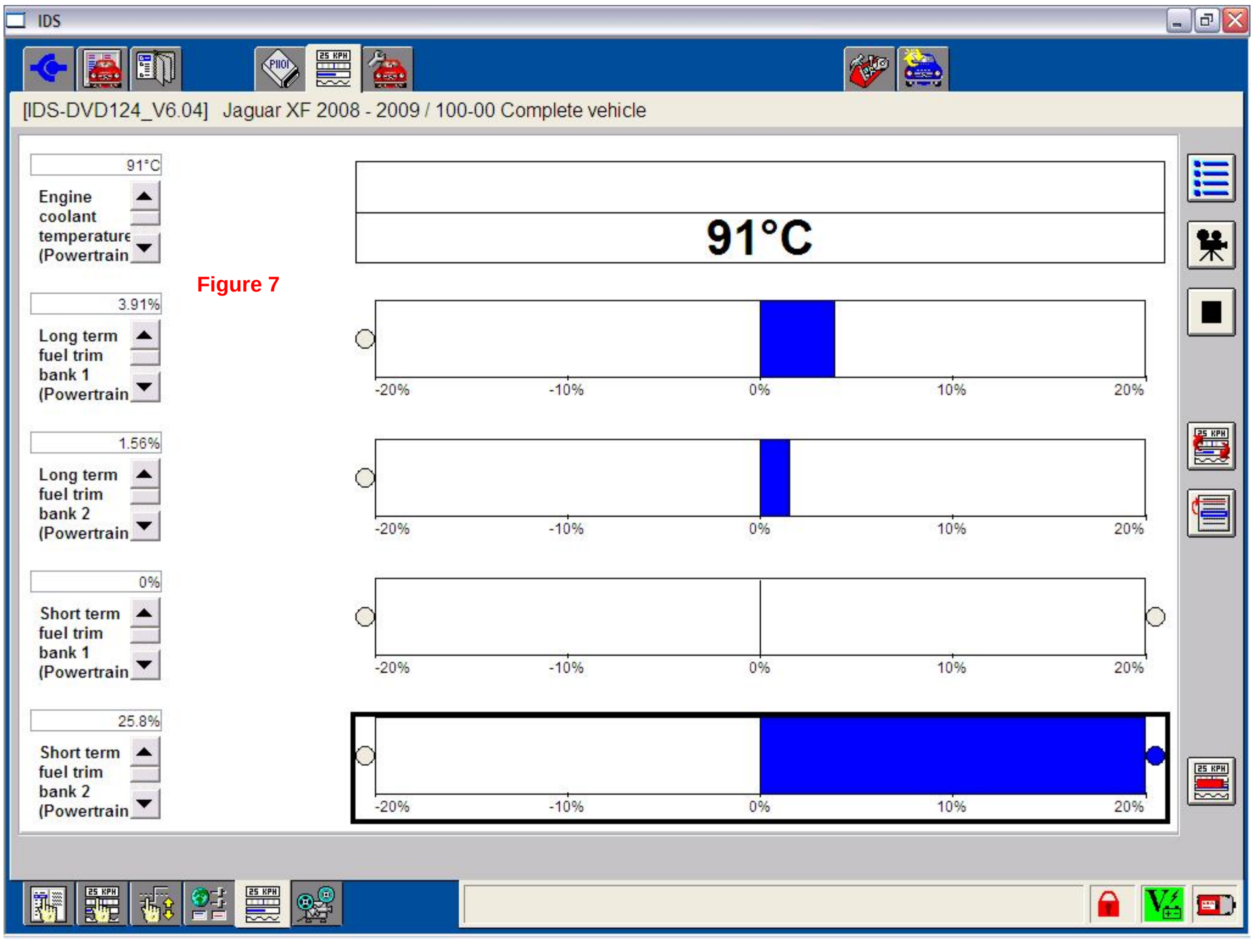


So, now you have a very basic idea how the fuel trims work on a late model car. To a technician, they are invaluable. They are the first place to look to either tell whether something is amiss, or in some cases more importantly, confirm that things are performing EXACTLY as they were designed. There just isn't much [if anything] that can go wrong and not impact fuel trims. Face it, if it doesn't affect the way an engine burns fuel and oxygen, how much of a problem can it be??

Now, here's a test. Don't look at the last page just yet. I have another illustration. I "engineered" another fault. On the same car, I disconnected the first ignition coil on the LH bank of the engine. That, of course removed the spark from one cylinder on that bank causing a misfire.

What did the fuel trims do???

Here's the result!



Ponder that for a while, and if you like, post for discussion.

MOST technicians understand that result right away. Others will need to think about it some before they get their head wrapped around it. It just shows that the first thought isn't always the right one.

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