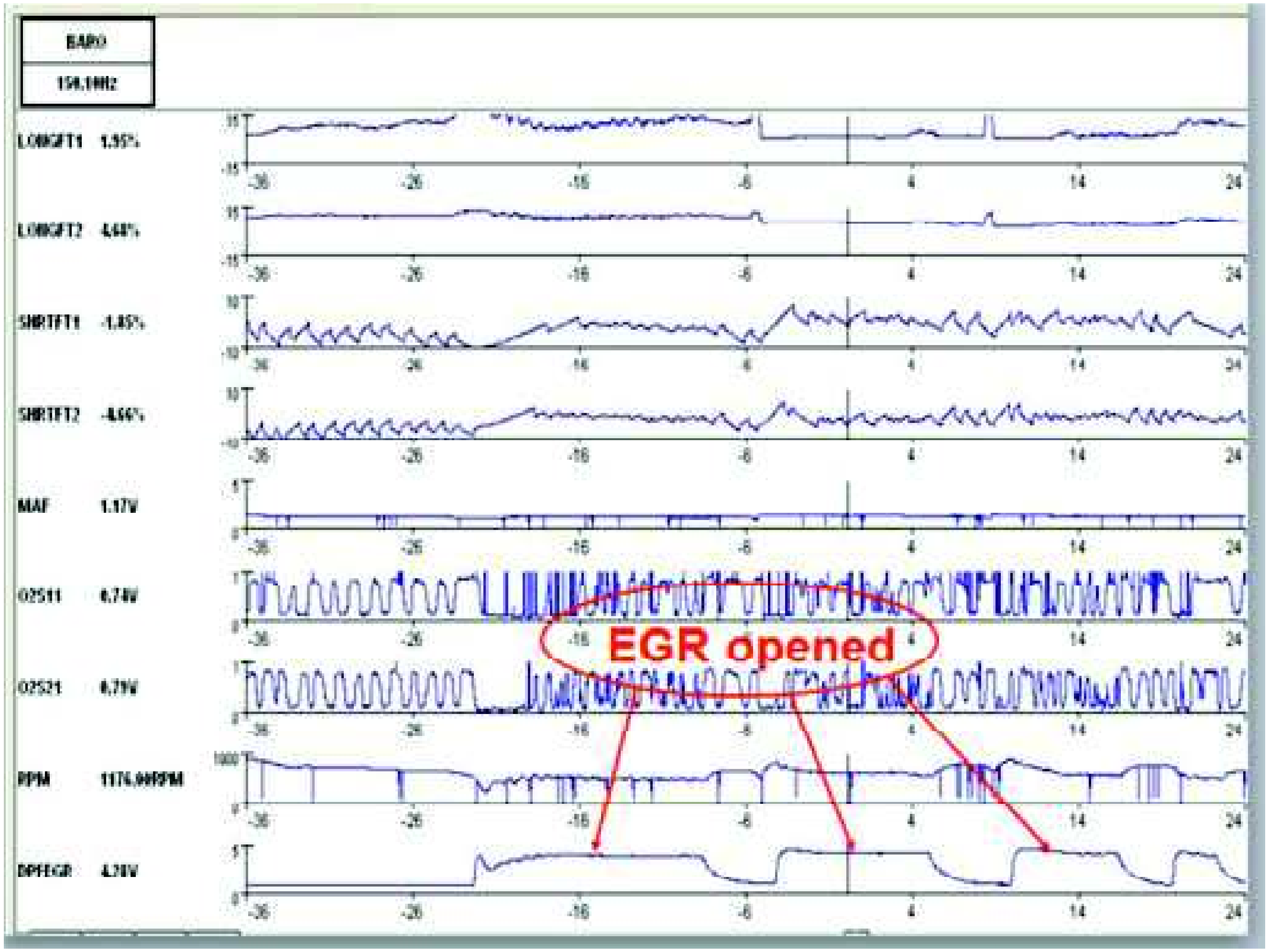
Fuel trim analysis & MAF testing

Using your scan tool with fuel trim graphs is a great way to get a quick and accurate direction to the real problem.

Albin Moore June 5th, 2012

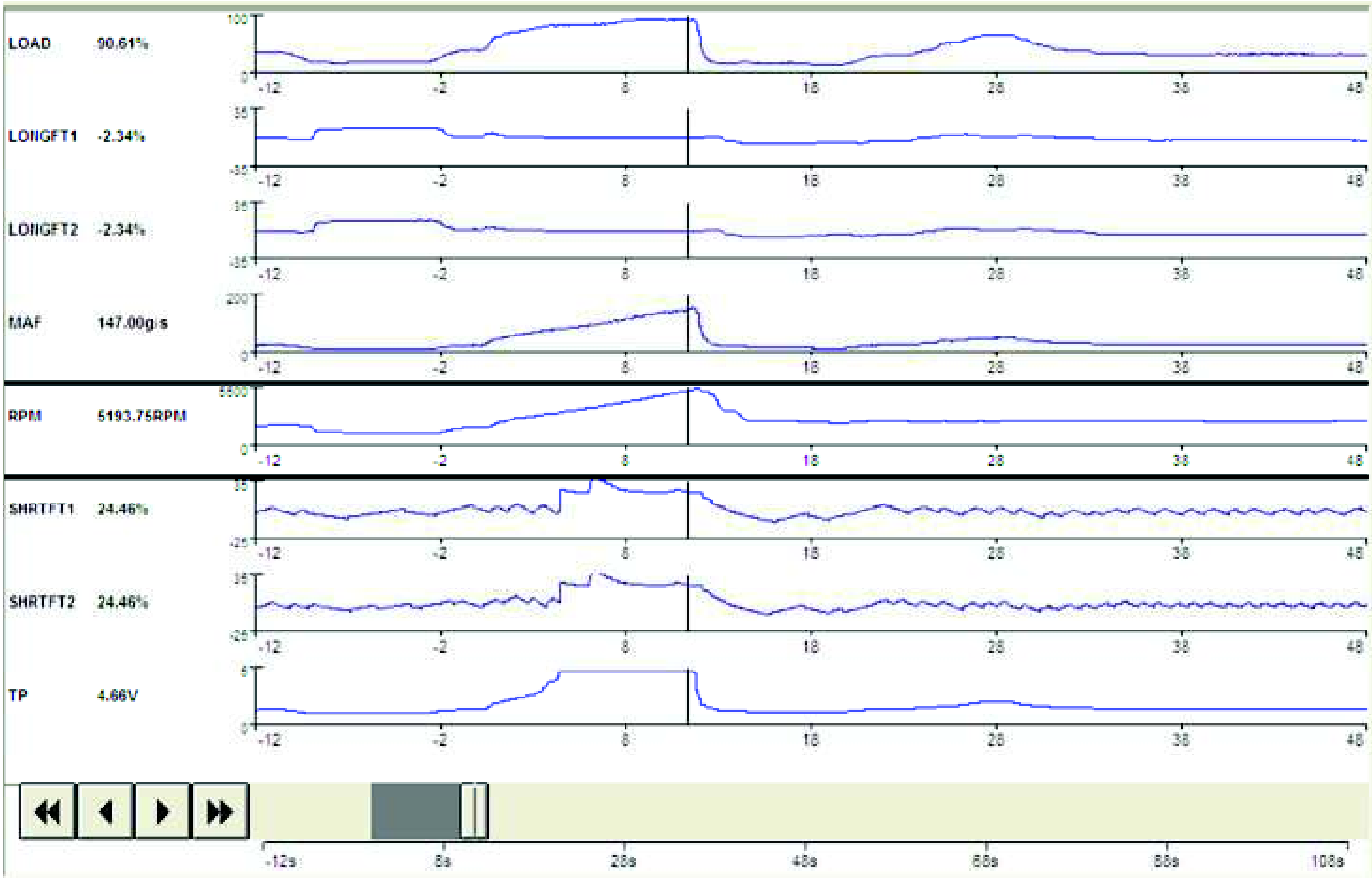
Thinking back over the years, my first encounter with fuel trim information was the General Motors block learn and integrator. My impression of this data was, “It is meaningless.” I think this opinion was formed from lack of information and lack of training. About 10 years ago, I was introduced to fuel trim data and the power of the scan tool.



Before I start this discussion, I want to go over a little of the theory of fuel trim; where it comes from, what is it doing and what it will tell us as we graph out the data on the scan tool. While I am talking about scan tools, I do recommend that you use a scan tool that will graph the information since the trend of the data can be as important as the numbers as we troubleshoot drivability problems. It has been said that a picture is worth a thousand words, and in this case that saying has never been truer. Another benefit of graphing data is you have a record of the broken vehicle and you are also able to use the same test data to verify the problem was fixed properly.

The main object of fuel control is to control the air/fuel ratio so the engine will run smooth, efficient and produce good power all while producing a clean flow of exhaust gasses. To accomplish this small feat, the fuel control system will use sensors like engine coolant temperature, intake air temperature, throttle position, manifold absolute pressure, mass air flow and lambda sensors in the exhaust. All of these sensors input the data into the Engine Control Module (ECM), which processes the data and in turn operates the fuel injectors.

To be able to calculate the air/fuel ratio, the ECM needs a starting place. Since the gasoline engine is an air pump, it's easiest to start with the calculation of the air mass. There are two different methods used today; the mass air flow method, and the speed density method. The first method is quite simple. The Mass Air Flow (MAF) sensor measures the weight of the air entering the engine, and the ECM controls the fuel injectors to achieve the correct air/fuel ratio. The speed density method is a little more complicated. It uses a manifold absolute pressure sensor, engine volume, and throttle position to calculate the weight of the air flow into the engine.



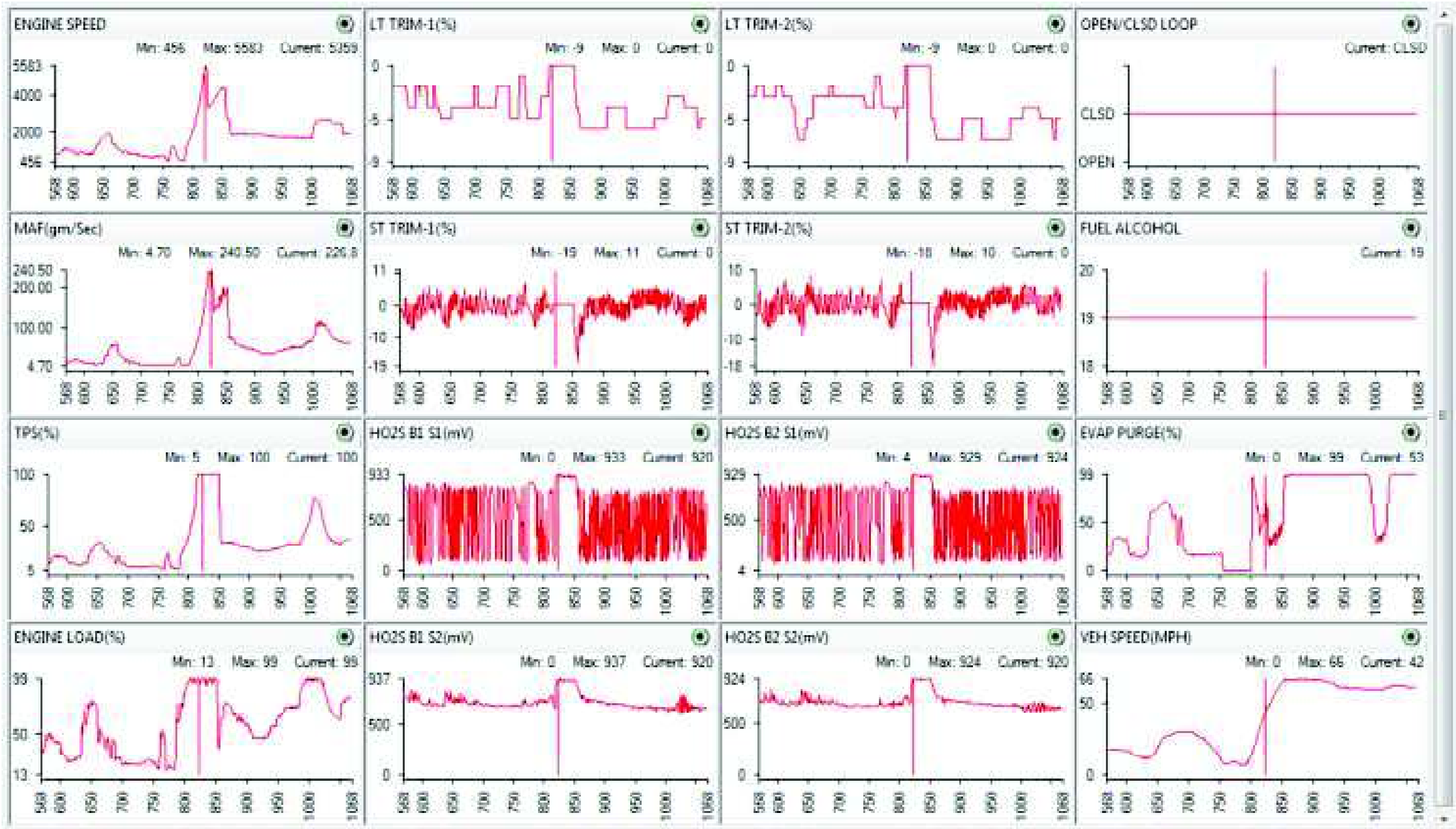
The MAF engine measures the actual air that is flowing through the MAF sensor. Things like restricted air intakes, restricted exhaust and EGR flow will not affect the air/fuel ratio. Take a look at the scan data where I have opened and closed the EGR valve. Notice that there is no fuel trim shift when the EGR is flowing. The EGR acts as cylinder filler and the air that is entering the engine has the proper amount of fuel injected to keep the air/fuel ratio correct. However, air leaks that happen any place between the engine side of the MAF and the intake valves will cause the system to run lean. This is because the air leak is allowing air to enter the engine without being first measured by the MAF sensor (also referred to as “unmetered air”). The lambda sensor that is mounted in the exhaust stream will see this extra oxygen and cause a positive trend to the fuel trim.

The speed density system plays by some different rules. An air leak into the intake manifold will not cause any change in the air/fuel ratio since the air leak is seen by the ECM the same as opening the throttle blade a little. Because there is an exception to every rule, an air leak can cause a lean condition if it is at an intake runner very close to an intake valve. This will cause a very localized high pressure in the intake manifold, which the MAP sensor will not detect and that one cylinder can run lean.

A restricted air intake system will not cause the air/fuel ratio to change, because the restriction is seen the same as throttle position (that is, both result in reduced air flow to the engine). Things like a leaking EGR valve or a restricted exhaust will cause the air/fuel ratio to go rich because these two things will cause the manifold pressure to increase (manifold vacuum to rise) and the MAP sensor will sense a high engine load and in turn the ECM will allow more fuel to flow through the fuel injectors.

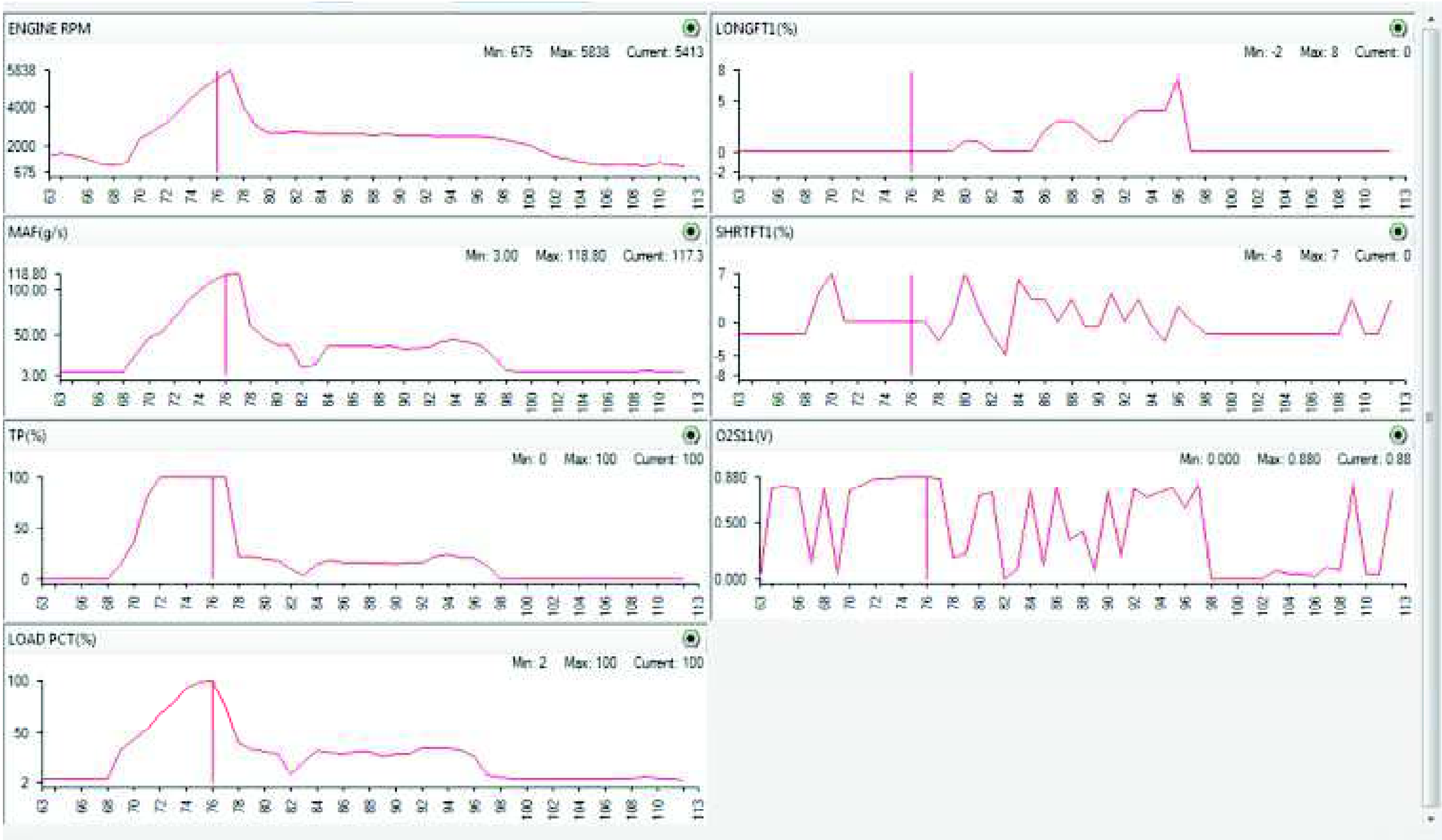
The Who, What, Why of Fuel Trim Data

Short-term fuel trim (STFT) is the product of the feedback from the oxygen sensors. This is the real-time correction to the fuel injector pulse width that is commanded by the ECM. The long-term fuel trim (LTFT) is the accumulated data from the short-term trims. This is the historical record from the O^2 sensor feedback. This long-term fuel trim information is stored in fuel trim cells, which are data files taken at different engine speeds and loads. These fuel trim cells are used so the ECM can quickly find the needed information when the engine load is changed.



Many times we have heard that oxygen sensors sense oxygen. Well in a way they do, but in a way they don't. Oxygen sensors will react to oxygen, but they also react to the other gasses that are in the exhaust system. Things like hydrogen and carbon will cause the oxygen sensor to react, and unburned hydrocarbon (unburned gasoline) will cause the oxygen sensor to react differently. Knowing this will allow you to use the fuel trim information to analyze things like misfires or dribbling injectors.

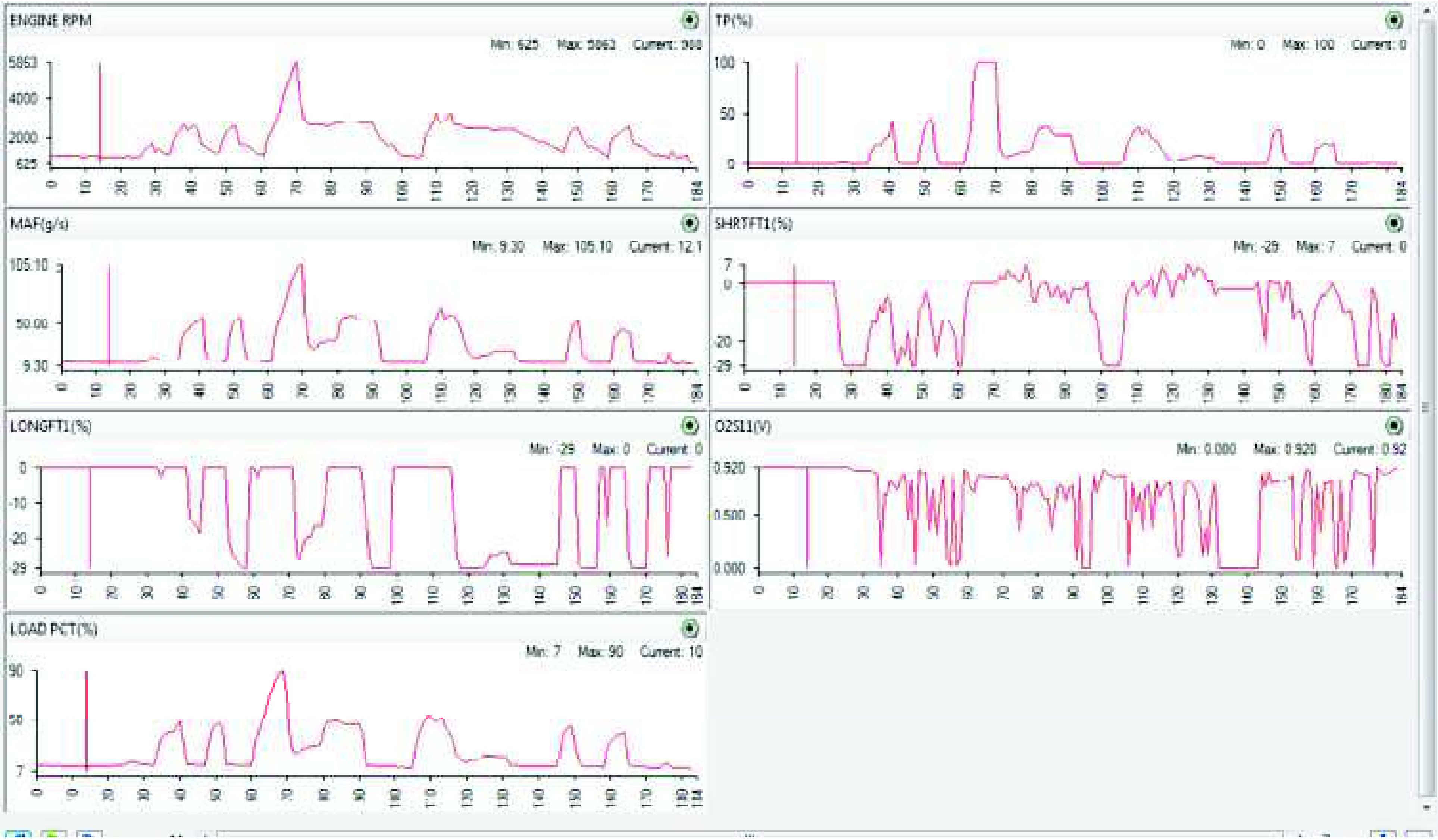
While I am talking about oxygen sensors, don't forget about the post-cat oxygen sensor. From time to time the PCM will use this sensor for fuel trim. This data is available on many scan tools and can be very useful when you are working on drivability problems. The use of the rear oxygen sensor for fuel trim started around 1988 on the Toyota Van wagon. If you ever get one of these in your bay, take a look and there will be an oxygen sensor behind the cat. This sensor was put back there to aid in keeping the catalytic converter healthy and happy.



Fuel Trim Analysis

Now that we have a background on how fuel trim works, it will be easy to apply the theory to the problem. We know that an engine needs fuel and air to make power. The air entering the engine is metered, the fuel injectors inject the fuel into the air stream and the oxygen sensors give a feedback to the ECM, which makes it possible for the ECM to either increase or decrease the fuel injector pulse width to keep the air/fuel ratio correct and the tail pipe emissions nice and clean.

I refer to this as the fuel control circle. This little dance goes on and on, over and over as the engine runs. If we hook up a scan tool to the data link, it is possible to see this action/reaction taking place as the engine is put through different engine speeds and loads. Being able to graph this data out on a scan tool will help you to get a quick direction when a drivability problem occurs.



Before we get started trying to use scan data to fix a broken car, we need to know what is good. This is true with both scan data and when using a labscope for testing. If you only pull out the test equipment when you have a broken car, you are probably not going to be able to get much good out of the tools. You need to be practicing on cars that are not broken. This playtime might seem like a waste of time, but consider how children learn. Many times they learn by playing and just letting their minds wander and be creative.