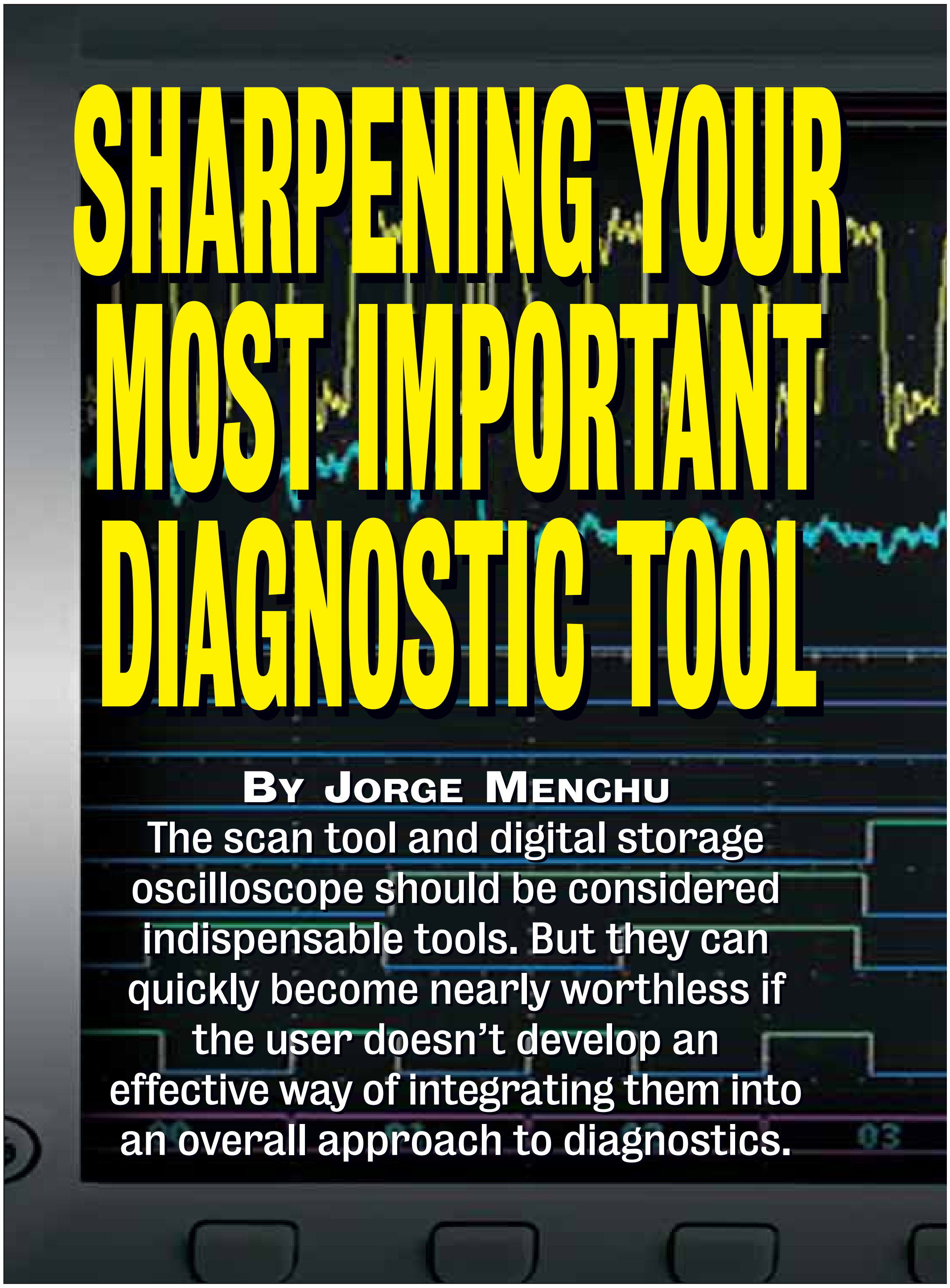

SHARPENING YOUR MOST IMPORTANT DIAGNOSTIC TOOL

BY JORGE MENCHU

The scan tool and digital storage oscilloscope should be considered indispensable tools. But they can quickly become nearly worthless if the user doesn't develop an effective way of integrating them into an overall approach to diagnostics.

One characteristic of a great automotive technician is the ability to perform efficient and effective diagnostics. These techs seem to know what they need to know and the tools and tests to get it. Of course, this is partly due to an accumulation of meaningful experience—experience based on real understanding.

One of the skills that distinguishes an expert is a knack for finding the relevant details of his diagnostic experiences and making the "connections" and "putting the pieces together." These abilities are what lead to an in-depth understanding of automotive systems and to "meaningful experience." Can we do this for ourselves? Certainly.

In this article, I'm going to present a fundamental framework for the basis of the behaviors that I believe will lead us to become diagnostically the best we can be. It's based on these elements:

Goal: Become the best I can be diagnostically (in the shortest amount of time).

How: Learn to "put the pieces together" so I can develop an in-depth understanding of automotive systems.

Mindset: I'm not going to spend my career as a go/no-go gauge dependent on others. I'm going to be a diagnostic learning machine.

Perspective: Diagnostics is not just about the fix; it's about the fix through understanding.

The Tools for Success

To accomplish our diagnostic tasks, it's important to have the right tools. They are the interface between us and our ability to put the pieces together. The diagnostic tools on the top of the list are the scan tool and the lab scope.

What makes these tools particularly valuable is that, when used together, they give a unique and complementary perspective of any automotive system that's being diagnosed, right from the system's core information pipeline—from the nuts & bolts that make up the mechanics of the system to the strategies that run it. In Fig. 1 on page 36, we can see how the scan tool and oscilloscope allow us to understand the functions of the PCM, the circuit wiring and related circuit components.

Scan Tool. We're all familiar with the scan tool's text, discrete values format and the smarts that come with using it. It's a powerful tap into the brain at the center of the automotive system, giving us the software's perspective. In general, the scan tool is certainly strong on the system strategy side and relatively weaker when it comes to the details of the mechanical side of the system.

Lab Scope. A lab scope taps directly into the information and energy pipelines of the system—the circuits. A key characteristic is the extreme detail offered by the line drawing format, in which even the smallest changes can be crucial information. The result is a detailed insight into the technology's perspective of the system. The lab scope is

Photoillustration: Harold A. Perry; images: Thinkstock

very strong on the technology side and relatively weaker on the strategy side.

When we combine the characteristics of the scan tool and the lab scope, we discover three applicable values: They provide different perspectives of the same problem, they complement each other's weakness and each tool extends into depths of the system where the other does not.

For diagnosis, the scan tool typically is connected to a vehicle before the lab scope, and the scope is used to complement the scan data in several ways. First, it *validates* the values in the scan data. The scan tool interprets the information from the PCM; the PCM reports information from the circuit. The displayed values of either one can be incorrect. The waveform from the scope can be used to validate the quality and values of the signal to the PCM.

The lab scope also validates expected actions. Scan data indicates a command sent to operate an actuator. Did it actually accomplish this goal?

The second way the lab scope complements the scan tool is by *pinpointing a problem* in a circuit. While the scan tool's code points to a problem in a circuit, the scope's waveform pinpoints it. Take, for example, a code for a high-side short in an injector circuit. A lab scope pinpoints the exact components that are failing and confirms those that are still functioning properly.

Finally, a lab scope *fills in the blanks* not covered by the scan tool. The PCM monitors certain aspects of the system. The lab scope can be configured to monitor almost anything; the detail of the waveform offers insights into the details of the system. For example, a scan tool reports charging voltage; a lab scope zooms in on alternator diode performance.

Here's another very powerful way to look at all of this: The PCM is connected to the rest of the vehicle only through the electrical circuits, as illustrated in Fig. 1. All of the smarts to operate the system, including the energy and information, have to go through the electrical circuits.

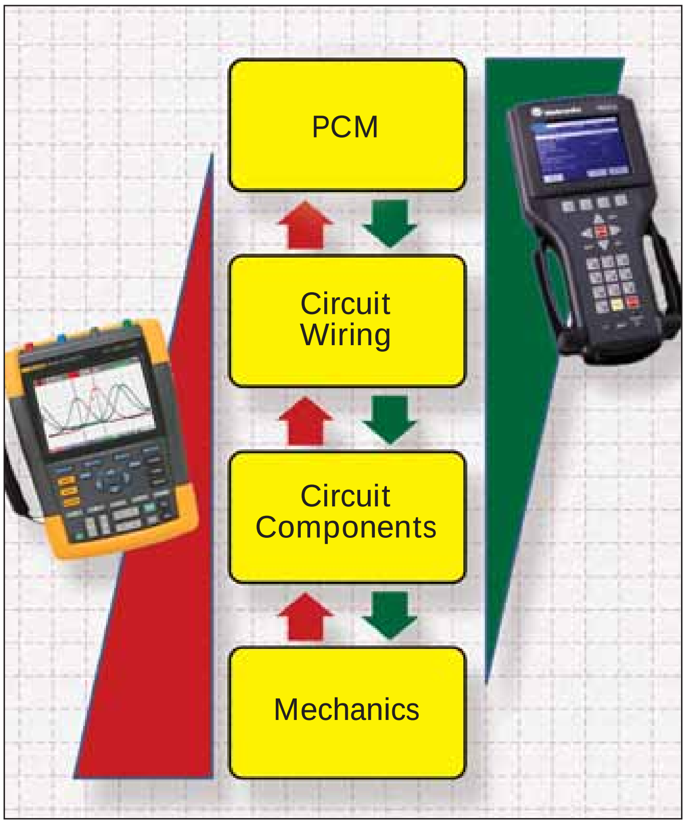

Fig. 1

Illustrations & waveform: Jorge Menchu

Working without either tool (scan tool or lab scope) is like working half-blind, especially when it comes to learning about the system, as well as for many diagnostic situations.

Getting Your Tools Up & Running

I expect almost everyone reading this article has access to or owns a scan tool. But what about a lab scope? It's been said that we're only as good as our greatest weakness. If you do have both a scan tool and a lab scope, it would certainly be unfortunate if the greatest weakness turned out to be the one easiest to overcome: the ability to operate them.

Here are a few tips for getting started: Set up your workspace so your tools are accessible and convenient to use. If they're not, you're less likely to get them out when under time pressure. This is especially important for laptop-based tools. You don't want to make a job more stressful because you haven't figured out how to fit the tools into an active workspace.

Master the "buttonology" ASAP. It's hard to focus on a tough job when you're trying to figure out what feature you need to access and what button to hit to get it.

Master the features, too. Do you know your test equipment's capabilities? The tool is there to give you diagnostic power; make sure you're getting the most out of it by understanding its features and options.

A key to getting over these challenges is getting your tools out before you need them. In fact, until you're comfortable with them, get them out and use them every chance you get.

During the learning process, especially with a lab scope, you'll see mostly "known-good" waveforms. These are essential parts of your waveform analysis foundation.

When you go to classes or read a case study, keep an eye out for the new diagnostic tools and learn how their features are being used.

Reading the Data

What do we do with the scan and waveform data once it's in our heads? Here's a brief outline of how we put the pieces together:

- We gather data, then give it meaning by relating it to the system and other data.
- Next, we gather enough additional data to fill in the blanks.
- At some point, we have enough data to understand how the system works.

Now let's focus on some details, techniques and behaviors for accomplishing this.

Thinking In Relationships

Beyond comparing specs to a spec chart, the value of test data is determined by our ability to relate it to what we want to accomplish. Even advanced waveform analysis is simply the practice of making finer and more detailed relationships. So it seems that to get the most from our diagnostic experiences, it's advisable to be in a heightened state of awareness.

A good place to start is to put the word *relationships* at the forefront of your diagnostic thoughts. Then build on this by training yourself to ask active questions that will help guide you, such as: What can I relate this to? How does this relate? Can I relate this to that? Here are some practical examples:

- How does the current in a circuit relate to the buildup of a coil's magnetic field?
- How does the 5-volt frequency signal that's peaking only to 4.1 volts relate to the performance of the engine and the scan data?
- How does this bent VRS sensor wheel relate to the waveform?
- How does the block learn on a GM vehicle relate to the oxygen and mass airflow (MAF) sensors?

Dynamic Picture

To further enhance the capabilities of relationships, consider live test data as a dynamic picture of everything that's related to it. This is especially powerful for waveforms, due to the extreme detail. Check out Figs. 2A, B and C on page 38. Each of these items helps to influence the shape of the waveform or is influenced by it.

The waveform dynamically relates them.

Here's an example of two of these relationships:

The static *description in a manual* of a variable reluctance sensor: The waveform brings it alive through its detailed and dynamic movie of a running waveform.

The *mechanics* of the sensor includes its physical parts and mounting: The waveform dynamically represents the integrity of the sensor wheel profile and the distance of the pickup to the wheel. Change any of these variables and the waveform changes.

In these examples, the waveform adds to our understanding of the physical parts and supplements the static description in the manuals. As a result, we not only understand the parts and pieces better but we also learn their character and behavior.

When you think of a waveform from this perspective, it's easy to see why it has become such an important part of learning, diagnosing and communicating…just as scan data is essential for understanding the strategies and the system's perspective.

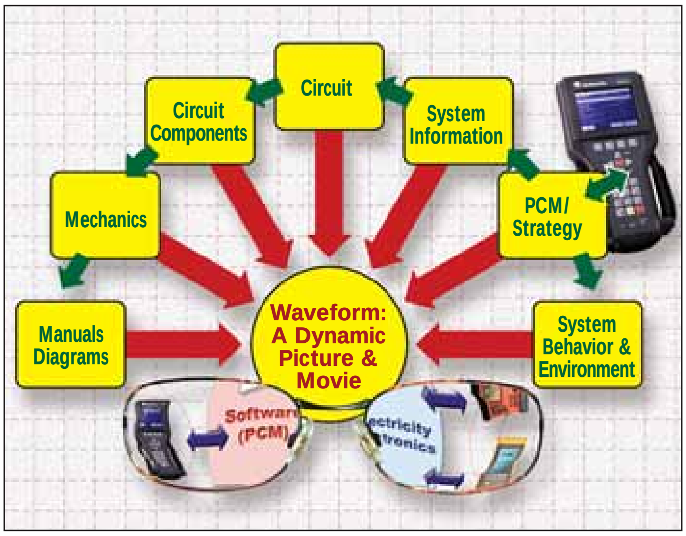

Fig. 2A

Thinking In Threads

At this point we've collected data and made relationships. The next step is to think in threads and/or processes, to gather enough pieces to reveal the sequences in which they fit and interact.

To help put this mindset into action, ask yourself these questions:

•Is what I'm observing an action or a reaction?

•What happened before "this" and what happens after?

•Where does "this" fit in to the process?

•What is the pathway for the information/energy/signal?

•What is the input and output?

Another strategy is to simply observe the processes that occur when the system is in operation.

This is also an important mindset specifically for diagnosis. For example, a failure in a system means a broken process. Diagnosis is finding where it's broken. A technique for doing this is to follow the processes of operation.

Here's an example of a no-crank on a simple starter circuit, from the "learner's" perspective: The process of turning the key results in a running engine. But on the next start, we turn the key and nothing happens. If we're not familiar with the system, we could literally follow the flow of energy by following the wires—starting at the battery and every step of the way to the starter, perhaps—a voltage test to see if the voltage disappears. At some point, the broken step in the process will be revealed—voltage in and no voltage out, or voltage in and no action out.

A Full Systems Approach

To this point we've discussed the tools and how they're used to gather data. Now, let's wrap everything up into a "full systems approach." The overall concept of the approach is to take advantage of the different levels of information and analyze them in the way we naturally learn. This means following the same steps an engineer uses to design a system.

Engineer	Us
Develop an **overview** of the project.	A **target** for our actions.
Define the **functional** building blocks of the system.	A **framework** to work within. A **road map** to guide us.
Get into the **details** to design and build.	**Apply.**

Fig. 2B

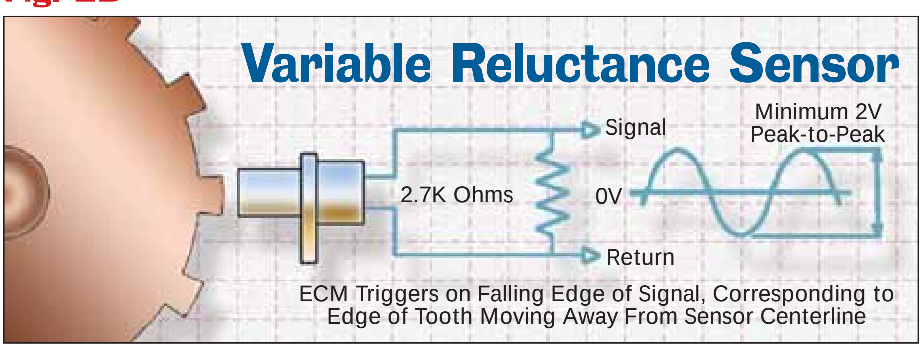

Fig. 2C

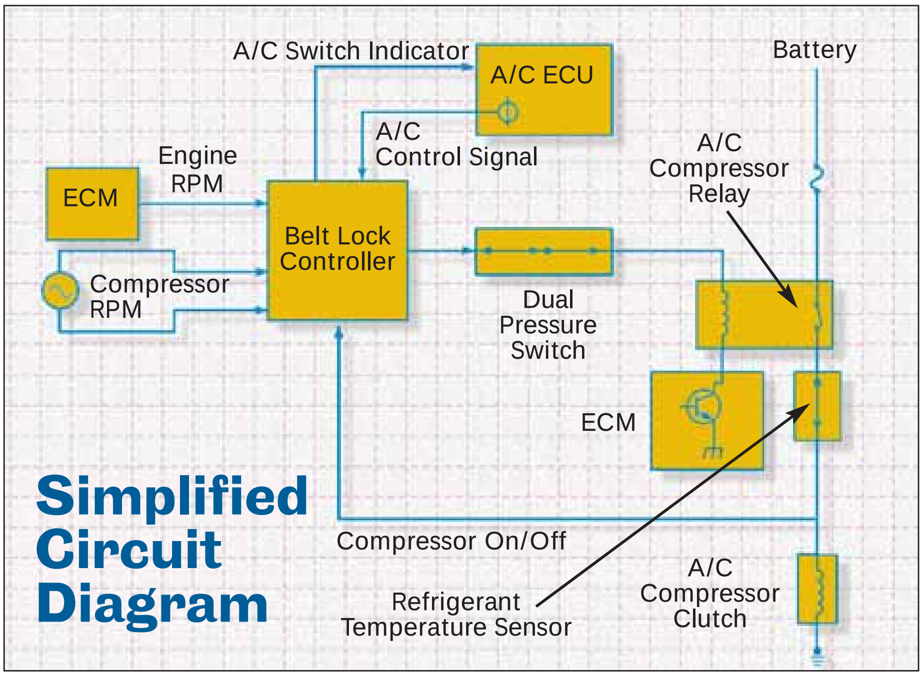

Fig. 3

Target. Defining the target means developing an understanding of how the system works. This information is typically found in a service manual's "theory of operation" and sometimes in a training module. It might include function, operation, behavior, variables, requirements and conditions. The actual target is to restore proper operation.

This is vital today due to high levels of networked integration among vehicle systems. We simply don't know what to expect because of shared data among individual vehicle systems. The question is, Do we want to learn it the costly way or the easy way?

Framework. A framework is basically the mechanics of the system operation. Ideally, the information is found in a functional diagram, such as the one shown in Fig. 3 above. It's like a wiring diagram without the detail. Ideally, it's supplied within a system's theory of operation.

Functional diagrams typically include:

•The key components involved in the function of operation, including networked devices.

•The relationships of key components to each other—their placement.

•The operational flow of information throughout the system—the lines and arrows.

Unfortunately, functional diagrams are not always available. No problem; you can make your own. In fact, it's worth it to reinforce these thought processes. Here's how:

1. Bring together the "theory of operation" and a wiring diagram.
2. Pick out the main players of the system and the main variables (including the networked connections).
3. Draw boxes around the components to construct a logical layout.
4. Label each.
5. Draw arrows to show the relationships indicating the flow of information. And always identify data line connections.

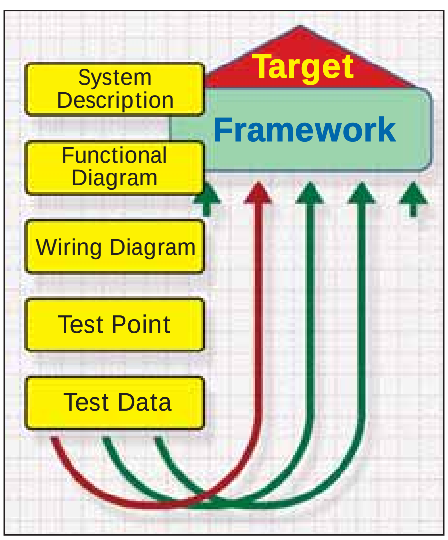

Fig. 4

Road Map. The arrows of the functional diagram illustrate the basic flow of actions and information within the system. Using the road map will keep you focused and on track.

Here's how it goes for using a lab scope (Fig. 4 below):

1. We understand the theory of operation and know the diagnostic target.
2. Use the functional diagram as a guide and map for testing based on the flow of information within the system.
3. Consult the detailed information of a diagram to identify the exact test point.
4. Go to the test point on the vehicle and gather data.
5. Plug the data into your understanding of the system, which is graphically displayed in the functional diagram.
6. Repeat until done.

Conclusion

Let's go back to the "turn the key and nothing happens" example (page 38), but this time from the point of view of the "expert" instead of the "learner:"

The expert has already mastered the understanding of the parts and pieces of the system. He understands how the parts work together to carry out the system processes. There's already a functional layout of the system in his mind. He doesn't have to follow the "flow of information" from the start if he doesn't want to. He can literally test any point in the system and still know where he is within the system processes. He understands the implication of the test results. He can quickly isolate the problem.

Most of us already understand the operation of a basic starter system. If you do, too, does the above description apply to you also? If so, perhaps you know what it is to be an expert (on a particular system). You also know the rewards of true understanding, which are efficiency and effectiveness. It also means this article is about something you already do, naturally.

This article can be found online at *www.motormagazine.com.*