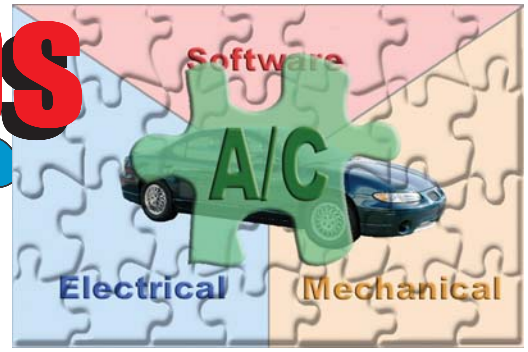
Building Better Relationships



A lab scope can improve your diagnostic skills. A picture is always better than a bunch of numbers, but it's all about knowing what you're seeing.

by Jorge Menchu

As an A/C system specialist, you have been (or will soon be) faced with the challenge of understanding computer-based system strategies. Understanding these takes a lot more than looking at a wiring diagram or following a predefined test procedure. In fact, due to system integration, you will have to broaden your knowledge well beyond A/C systems.

As a professional and specialist, there is no doubt that you are driven to master the challenge. You don't want to be a mindless slave to the manual's diagnostics, and you know that keeping up with technology ensures that your skills and toolbox are up to date.

Even if you are just making the transition from nuts and bolts to software and electronics, you've already figured out the value of a scan tool. The scan tool allows you to tap into the on-board diagnostics and lets you see into the system. It's a must-have item.

The Dynamic Duo: The scantool offers a dynamic perspective of the system from the system's software view. The lab scope offers a dynamic perspective from the circuit's view.

A lab scope, on the other hand, is usually the last tool that techs add to their knowledge-building toolbox. Yet it is as important as a scan tool and, in some ways more important. Lab scopes offer an interpretation of the system from the circuit perspective. Having that view can tie together many aspects of diagnosis, including electronics, information in the manuals, scan tool/strategy info, and the physical system.

Beyond specific testing, a good lab scope is a tool for learning. You will have mastered the lab scope when you know when not to use it.

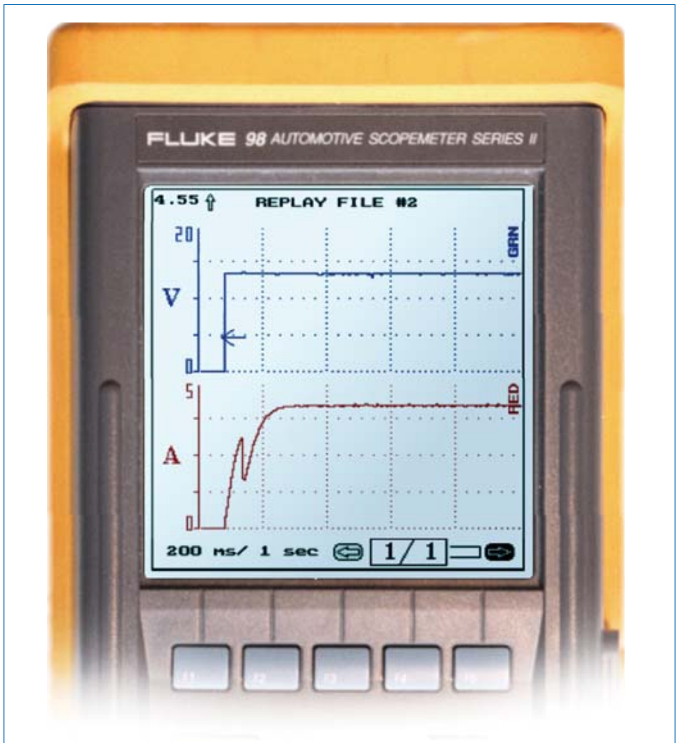
Getting Started

So, how do you get started with a lab scope? Start with the right perspective. The biggest mistake of many first-time users is thinking that the scope shows something they don't know. Instead, think of the lab scope as another way to see what you do know. You already understand A/C systems, and you have expectations as to how the system should behave. Now, form a relationship between what you know and what you see in the waveform.

Simply looking for relationships is a big part of waveform analysis. You don't even have to know much about electronics to get started. Here is a simple non-A/C example to illustrate: if your scope is connected to a throttle position sensor and you press the gas pedal, it is easy to see the relationship between the pedal position and the signal. If a drop-out appears on the screen, the relationship is broken; something is wrong. You don't need to know anything about electronics to make that conclusion!

Even if you don't know much about electricity, you will be amazed at how all the random knowledge you have picked up from seminars, books, and other sources will start to fit together. The waveform turns electricity into something more tangible than numbers on a DMM, especially if you use an amp probe along with your voltage testing.

Let's examine a simple voltage and current waveform of an AC compressor clutch (Fig.2). I purposely selected a device and circuit that almost everyone is familiar with.



The top waveform is voltage and the bottom is current. Each offers unique information about the circuit and system.

Let's start by seeing what the "printed" or frozen waveforms offer. They are different from what the scope offers live. This will illustrate what each one contributes individually.

"You don't even have to know much about electronics to get started."

Voltage Waveform

The voltage waveform shows a simple low-to-high transition that indicates circuit activation. Since the signal goes high when the circuit is activated, it must be a switched-power circuit.

You can also think of this rise as a pictorial representation of all of the requirements that have to be met for this system to be activated.

After activation the signal stays steady, but there is no clear indication of any work being performed. In other words, from the voltage waveform alone, there is no indication of current flow. There might be current or there might not. Therefore, you must conclude that the voltage waveform only indicates the intent to energize the circuit. To make any other valid conclusions, you'll need more information or another way to qualify it.

Current Waveform

In the current waveform, not only can you see the intent to energize (the fact that current starts to flow), but since you have a measurable current, you know some reasonable level of work is being performed.

You can consider the current waveform as a graph of the amount of electrical energy used to perform work.

The next question is "what type of work is it doing, and is it doing it well enough to accomplish its intended goal?" You expect it to be energizing and locking the clutch of course.

This current waveform has a few clues to how the energy is being used. The most obvious indication is the initial ramp. A ramp such as this is a signature of a coil, as we would expect. Think of the ramp as a graphed representation of the magnetic field building up. Another indication of events is the notch halfway up the ramp. What event takes place along the timeline of the magnetic field building up? Could it be clutch lockup?

Other important information includes the overall level of current and the fact that it is steady. A steady current signal indicates the integrity of the coil under load for the displayed period of time. We know that due to heat, coils sometimes fail under load In this case we know the coil (or circuit) did not break down for 4 seconds.

Both Waveforms

These waveforms were captured together. They qualify each other and offer a whole new level of analysis compared to taking each one individually.

From the voltage waveform you can now judge the integrity of the circuit between the test point and the power source. The current waveform shows that the circuit is under reasonable load. Since there are no drops in voltage, you can conclude the there are no resistance problems for this part of the circuit at the present load.

Also note the relationship between the current and voltage tracks — there's no notch in the voltage! This gives weight to your suspicion that the notch is related to clutch engagement; the movement of the clutch disrupts the magnetic field.

Forming an Overview

You can make some pretty good judgments regarding circuit integrity from just the waveforms. Still, each waveform viewed alone or just on paper has unique limitations. Now imagine the scope is in your hands and the sounds, sights, and smells of the vehicle are in front of you.

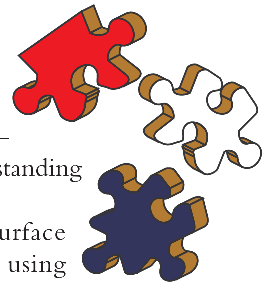
Although the waveforms are encouraging, you still can not conclude for certain that the A/C compressor is spinning. The final qualification for the waveforms, and certainly for the system, is what you see and hear. The sound of the clutch lock up is a great indicator of circuit integrity and an important part of the waveform analysis. Did the clutch engage quickly with a clean strong snap? Is it actually locked up?

Since locking the clutch is the goal of the circuit, what we see and hear is the final qualifier for the waveform. It is informing us exactly how the energy of the circuit is used. In fact, if you don't have a current probe, what you see and hear qualifies the voltage waveform to a great degree. If the clutch engages strongly and the voltage waveform stays steady, the integrity of the circuit between the test point and the power source are likely to be good.

Relationships

As you practice this relationship method, you will see that it extends to almost all parts of waveform analysis in one way or another. To reinforce it, simply learn to ask yourself, "What's the relationship?" And remember, this includes what you hear, see, feel, smell, expect, and know.

That brings up another important point: did you know that most electrical components have unique ways in which they shape a waveform? By paying attention to the components in the circuits and making of their electronic signatures, you will start to recognize their role in shaping the waveform. You will develop the ability to identify incorrect circuit function, as well as having a better understanding and feel for the components.



We have just scratched the surface regarding what you can see and learn using a lab scope. The bottom line: if you are not using a lab scope and your buddy is, who do you think will learn faster, diagnose better, and offer the customer a more thorough level of service? ■

"The waveform turns electricity into something more tangible than numbers on a DMM."

Jorge Menchu is president of Automotive Electronics Services, Inc. (AES), a company specializing in the sale and support of hand-held electronic diagnostic equipment. He also teaches courses in electronics, lab scopes and the art of learning. Many of his classes focus on developing the mental tools necessary to meet the complexity of today's vehicle systems. He has developed several electronic tools, and has received Motor's 'Top 20' Award four times.