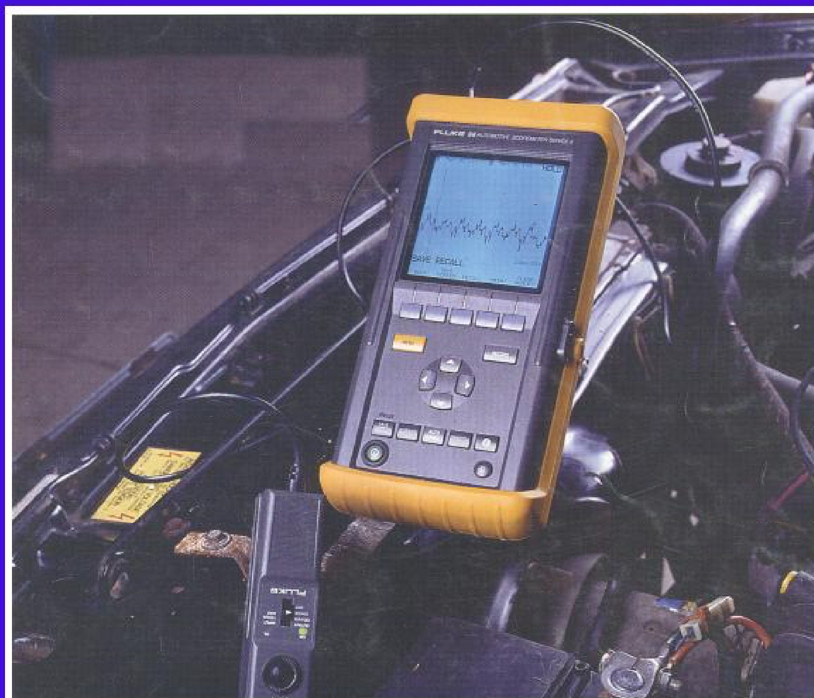
Clamping Down



An article by Jorge Menchu that originally appeared in the October 1997 issue of

IMPORT SERVICE

Clamping Down

As lab scope users get comfortable using their scopes and understanding voltage waveforms, they will eventually want to learn to use them in new and different ways. Of course one of the things that makes a lab scope so powerful is that you can connect it to many different transducers, including many devices that were initially meant for use with DMMs. This would include probes to measure temperature, pressure, vacuum, knock and noise sensors, and position and speed sensors. In fact, many surplus sensors removed from the systems you are already working on can be adapted to serve as input devices for your scope. If you are ready to start experimenting beyond conventional time/voltage waveforms on your scope, a good place to start is with current waveforms. After that, you may want to look at vacuum waveforms.

Current Probes

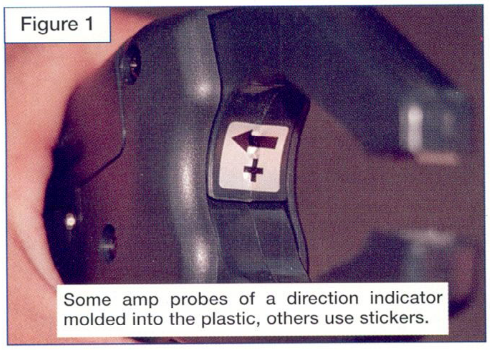
Current probes (also known as amp probes) read the current of a circuit as you would expect. These probes can be very helpful in many types of circuits, especially when you are diagnosing circuits whose voltage waveforms give little, if any, indication of circuit performance.

Most of today's current probes are considered non-invasive. This means you do not have to take the circuit apart to do a current measurement, you simply clamp the jaws of the probe over a wire in the circuit. The probe uses a Hall sensor which reacts to the magnetic field that is created by the current in the wire. These probes have a battery to power the Hall sensor circuit and to provide a voltage output to the scope. In the photo above, the fuel pump fuse has been removed, and a jumper wire has been installed. This allows us to clamp the current probe around the wire.

Connection to Circuit

The probe is sensitive to the direction of the current flow. If the probe is not oriented correctly, the direction of the current flow through the circuit will cause a waveform that is upside down. Therefore, it is important that the probe be installed correctly around the wire you are testing. Most probes should have an indicator near the jaws. **Figure 1** shows a B&K probe with a sticker indicating that the arrow should point toward the positive side of the circuit. If your probe's sticker is missing, simply flip the probe over if the signal is displayed upside down.

Figure 1



Some amp probes of a direction indicator molded into the plastic, others use stickers.

Probe Calibration

Even though a current probe reads current, it outputs a voltage signal to the scope. The voltage output is calibrated to the current levels. There is usually a calibration chart on the probe. Since most lab scopes only read voltages on the vertical scale, it is important to understand the calibration so you can set up the scope and analyze the waveform.

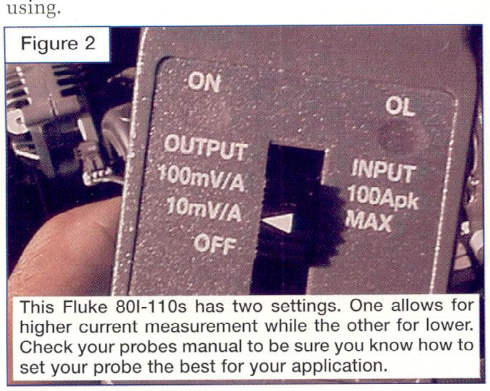
Figure 2 shows the calibration chart that is molded into the housing of the Fluke 80I-110s current probe. It has two settings:

• 100 mV/A - The probe will output a signal that is equivalent to 100 mV per amp. So, 5 amps will result in a 500 mV reading on the scope.

• 10 mV/A - The probe will output a signal that is equivalent to 10 mV per amp. So, 5 amps will result in a 50 mV reading on the scope.

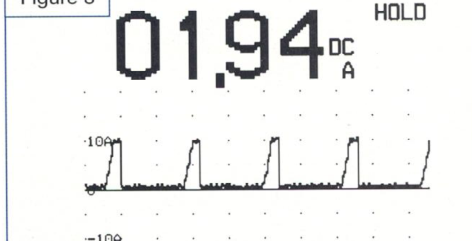
Some amp probes are calibrated at 1 mV/A. In the case of the Fluke 80I-110s, the 100 mV/A calibration has a maximum range of 10 amps while the 10 mV/A calibration can measure up to 100 amps. As you can see, with all of these different calibrations, it is important to pay attention to the probe you are using.

Figure 2



This Fluke 80I-110s has two settings. One allows for higher current measurement while the other for lower. Check your probes manual to be sure you know how to set your probe the best for your application.

Figure 3



The Fluke 98 can be setup to display measurement and setting values in amps. Notice the difference in the digital display to the actual waveform.

Figure 3 shows a captured waveform taken from a Fluke 98 Series II. Some scopes such as this one can be set up to calibrate the amp probe to the scope for you. Notice that all the values in the screen are based on amps.

On some current probes, there is a setting to 'zero out' the probe. This setting is used to adjust the output from the probe to equal zero volts. This is done before it is clamped on the circuit. Do not forget this step, especially if you are going to perform critical measurements.

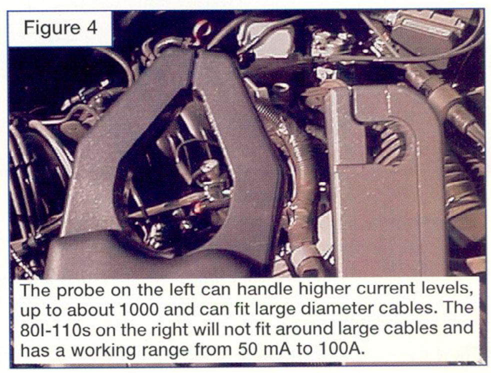
Connection to Meter

Many amp probes are designed to work with multimeters and will have banana plug connectors. These probes will work with your lab scope as well. For scopes that are equipped with BNC connectors, it is a simple matter of having the right adapter for the job. A simple banana plug to BNC connector quickly remedies this problem.

Ratings

All current probes have a limited range of opera-

Figure 4



The probe on the left can handle higher current levels, up to about 1000 and can fit large diameter cables. The 80I-110s on the right will not fit around large cables and has a working range from 50 mA to 100A.

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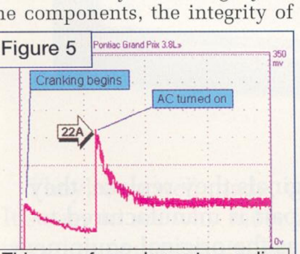
tion and some are more sensitive than others. For example, the Fluke 80I-110s ranges from 50 mA to 100A. Limited to 100 amps means you will not be doing starter draw checks with this probe. But with a low-end rating of 50 mA, you could use this probe to look at relay circuits. Other current probes can range up to thousands of amps (**refer to Figure 4 on page 9**). Because they are designed primarily for measuring high current flow circuits, these probes are usually not very sensitive at the lower ranges. As you can see, if you are thinking about purchasing a current probe it is a good idea to consider the application and working range of the probe.

Applications

Many sensor circuits in automotive systems are designed to work on voltage levels with minimal current and are best tested by measuring voltage. But actuator circuits such as relay coils, fuel pumps, cooling fans, and AC clutches do not give much of an indication of performance in their voltage waveforms. For these types of circuits, current measurement is the best way to electronically determine circuit performance.

Since the voltage and resistance of the circuit determine the amount of current in a circuit, and the amount of resistance is determined by the integrity of the components, the integrity of the circuit can be determined by measuring the current flow.

Figure 5



This waveform shows two radiator fan speeds. The peaks are the initial inrush of current.

Figure 5 is a good example of an application for the current probe. The calibration was set to 10 mv/A. When the engine was started, the fan was operating in low speed mode in response to the hot engine. When the AC was turned on, the fan sped up. The spikes in the waveform show the initial increase in current flow that occurs. As the fan motor revved up, the current demand settles. With the AC on, current flow settled at about 8 amps. If this system burned relay contacts, you could determine if the radiator fan pulled too much current or if it was just a bad relay.

Often the current specs for a particular circuit will not take into consideration the initial surge of current. For example, the specs might read 8 to 10 amps for this relay fan, but that does not take the initial spike into consideration. Most of the specs you will find are based on what you would expect to see on a DMM without special features. It is unlikely that the DMM would be capable of capturing the spike.

This can be confusing when you start to use a lab scope to capture current waveforms, so do not forget to take it into consideration. For example,if we were to monitor the current feeding the primary side of the coils on a DIS ignition system. A DMM reading might indicate a current flow of only 1.94 amps, yet a waveform of the same circuit would show peaks of 10 amps. DMMs usually sample a signal very slowly (2 to 4 times a second) and average the reading, unlike the lab scope's very detailed picture of the signal.

When performing current test on electrical motors, you can often determine the integrity of the contact of the brushes to the commentator bars. **Figure 6** is the radiator fan again. This time the time per division is set to dis-

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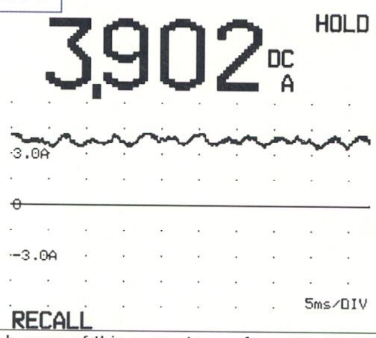
Figure 6



The humps of this current waveform are created from the action of the brushes to the commutator bars. The digital reading is averaged.

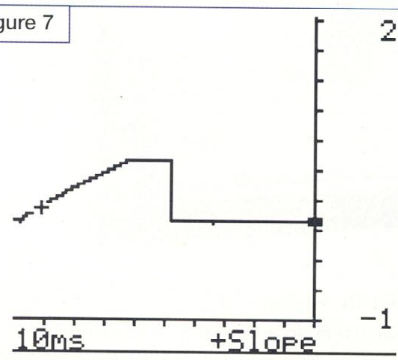
play the humps of the brushes. If a bar were bad you would see it every time it "came around." For example, if there were eight bars it would show up every eight humps. This technique can be applied to fuel pumps as well.

Figure 7 shows the current waveform of an injector captured using the Snap-On Vantage. The Vantage was set to Waveform Viewer with the calibration of 100 mV/A. Notice that there are no spikes as you would expect in a voltage waveform. That is because the spikes are the result of the coil's field collapsing into an open circuit. An open circuit means no current flow.

Current Probe Check List:

- Make sure the jaw is closed
- Stay away from ignition wires.
- Zero-out the probe.
- Orient the probe to the circuit correctly.
- Check your probe calibration.

Figure 7



This is an injector current waveform and was captured using the Snap-On Vantage on Waveform Viewer.

Figure 8

This is the Fluke PV350 pressure/vacuum transducer. It was designed to attach directly to your DMM. If it does not fit your scope, just use an adapter.

Pressure/Vacuum Traducers

There are a handful of pressure/vacuum transducers on the market. The one in **Figure 8** is made by Fluke and uses banana plugs to connect to your meter. It can read many things, from fuel pressure to manifold vacuum.

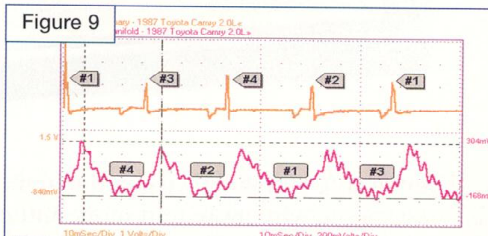
Just like the current probes, pressure/vacuum transducers output a voltage that is relative to what they are measuring. This makes it important to pay attention to the calibration so you can set up your scope correctly.

Applications

There are many applications for vacuum testing. A very popular use is to check running and/or cranking compression. **Figure 9** is a sample vacuum waveform taken from a 1987 Toyota Camry at idle. These waveforms were captured using the Fluke 97. To capture a running compression waveform:

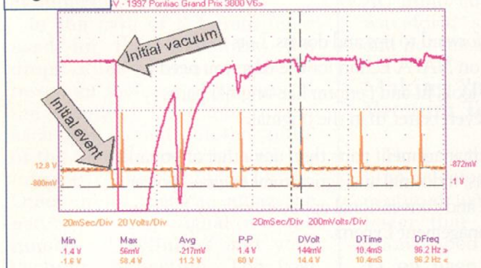
- The trigger pickup should be on #1 plug wire and connected into the external trigger input of the scope.
- Channel A should be connected to a centralized location on the cap to capture secondary ignition. The coil on this systems is in the distributor.
- Channel B was set to AC input coupling and con-

Figure 9



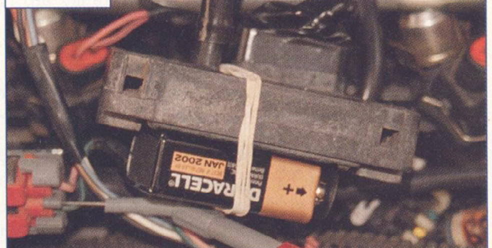
The top signal is ignition and the lower is vacuum. The companion cylinder causes the vacuum pulse after each ignition spike.

Figure 10



These waveforms are of a VSV. The lower signal is from the coil and the upper is the vacuum signal.

Figure 11



All the vacuum waveforms for this article were captured using this home-made vacuum transducer. OK, this GM MAP sensor is connected to a 9 volt.

nected to the vacuum transducer. When the scope is set to AC it will block out the steady signal and only show the always changing portion. This allows a lower volt per division setting so we can zoom in on the changes.

It is very helpful to use a separate trigger signal to stabilize the waveform. If you use a plug wire, you can cause each cylinders event to overlap itself on each update. If your scope does not have an external trigger input, connect your trigger pickup to #1 plug and to a display channel of your scope such as Channel A.

If you trigger from a plug wire, you can determine the owner of each vacuum event. The rule of thumb is this: For a particular ignition event, the following vacuum pulse represents the companion cylinder. For example, on this Toyota #1 and #4 is are at TDC at the same time, but when #1 is on power and #4 is on intake. These are companion cylinders.

In the case of the transducer used for this waveform, the drops in the vacuum signal represent an increase of vacuum in the manifold. The integrity of each drop depends on the "pull" of the working cylinder and the integrity of the seal of the others. Other things that can affect the nature of your signal are the number of cylinders and your vacuum connection. The best way to know whether you are looking at a good signal is to familiarize yourself with vacuum waveforms on known-good vehicles.

There are many other useful applications for a vacuum tester. For example, you could test the action of a vacuum switching valve. All you have to do is tee the vacuum transducer into the VSV line you wish to test. In the case of **Figure 10 on page 15**, the other channel was connected to the coil of the VSV.

To capture the waveforms in Figure 11, the scope should be set up as follows:

• Trigger set to Channel B, which was attached to the VSV coil.

• Trigger mode is set to SINGLE. This causes the scope to wait for the first pulse to the VSV coil. The scope takes a single picture and holds it on the screen.

• Channel A is set to AC input coupling. AC input coupling allows for a low volt per division settings so we can focus on the changing portion of the signal and see slight variations.

• Start the engine. When the VSV cycles, its waveform will be captured.

With the scope set up like this the first pulse to the VSV coil is the first one displayed in the waveform. Notice how the initial turn on was the strongest change in vacuum. Remember, when vacuum goes up, the signal comes down. Once the vacuum line was charged, each electrical pulse helped maintain the level.

Also, since the scope was set to AC input coupling, the vacuum waveform shows the changes and not the steady vacuum.

Making Your Own Vacuum Tester

The neat thing about these vacuum waveforms is that they were captured using a do-it-yourself-tester that was made from a known-good MAP sensor (**Figure 11 on page 15**). If you have a known-good sensor you can make one too. To construct your vacuum waveform probe:

• Locate a known-good MAP sensor that outputs an analog voltage signal. I used a MAP sensor from a GM vehicle.

• Consult a system wiring diagram to identify the sensor pins.

• Connect the power and ground connector of the sensor to a 9-volt transistor radio battery. Do not use the vehicle's electrical system for power because the scope will pick up too much noise that will degrade your vacuum waveform. Use tape or a rubber band to hold the battery against the sensor.

• Connect a wire with a small alligator clip or banana socket on the end to the signal and one to the ground-side of the sensor and you are ready for testing.

Conclusion

As vehicle management system strategies become more complex, the need for innovative testing procedures increases. Understanding how to adapt or connect special purpose probes to your scope allows you to devise innovative ways to tackle your diagnostic problems. I've tried to show you some of the things that can be done and how to do them. I hope this will encourage you to find new applications for your current and vacuum/pressure probes.

—By Jorge Menchu

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