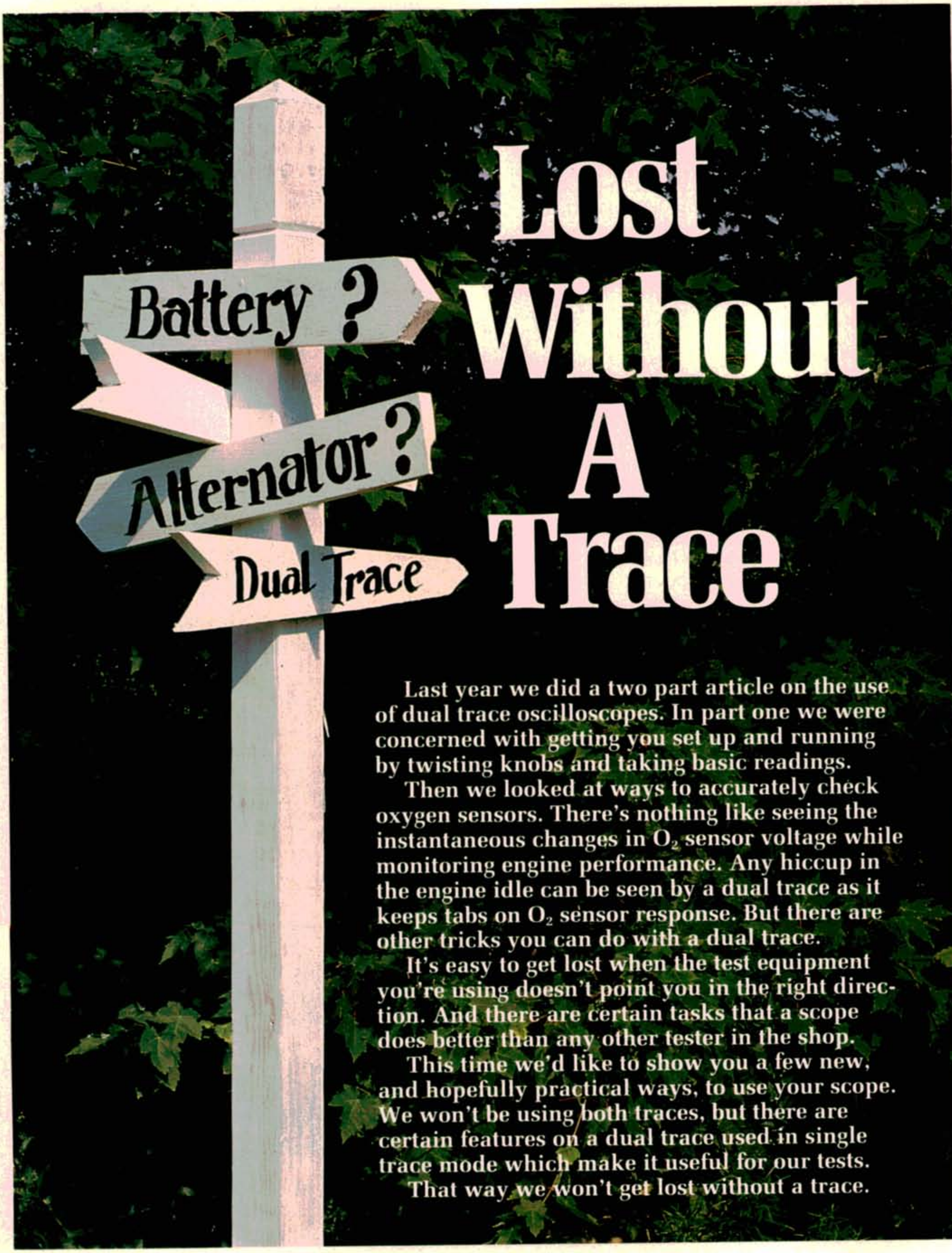


Lost Without A Trace

Last year we did a two part article on the use of dual trace oscilloscopes. In part one we were concerned with getting you set up and running by twisting knobs and taking basic readings.

Then we looked at ways to accurately check oxygen sensors. There's nothing like seeing the instantaneous changes in O_2 sensor voltage while monitoring engine performance. Any hiccup in the engine idle can be seen by a dual trace as it keeps tabs on O_2 sensor response. But there are other tricks you can do with a dual trace.

It's easy to get lost when the test equipment you're using doesn't point you in the right direction. And there are certain tasks that a scope does better than any other tester in the shop.

This time we'd like to show you a few new, and hopefully practical ways, to use your scope. We won't be using both traces, but there are certain features on a dual trace used in single trace mode which make it useful for our tests.

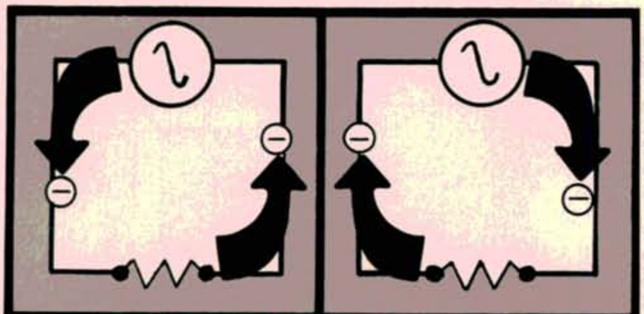
That way we won't get lost without a trace.

AC Versus DC

Batteries produce DC voltage. And DC has a constant polarity as indicated by the plus and minus signs on the battery. Battery polarity directs electrons through the circuit from the positive to the negative terminals (we'll stick with Conventional Theory). Electrons will only flow one way in DC circuits, and that's the important part.

AC is a different matter. It still uses voltage and current, but has its own set of rules. AC voltage occurs in cycles called Hertz. These cycles represent rapid reversals of polarity. For one half of an entire cycle the AC is positive. Then for the other half it is negative.

Each time the voltage polarity changes, the current changes direction in response to that change. First the current is pushed one way, then the other. The AC current flow is determined by the AC voltage at any given moment.



AC Reverses Polarity Each 1/2 Cycle

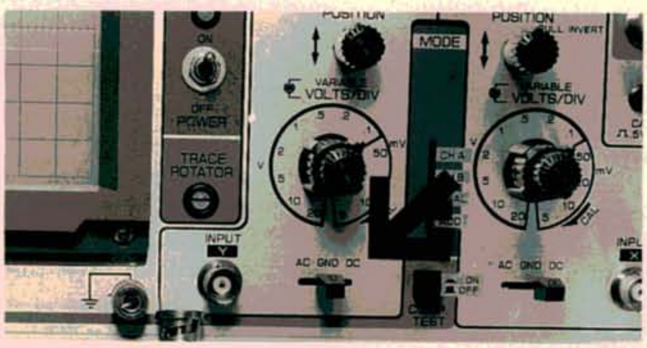
The AC/GND/DC Switch

The dual trace scope understands what's happening even if we are confused at the moment. It has an AC/GND/DC switch.

Here's what happens when that switch is in each of its three possible positions:

• **AC POSITION:** In this setting, the only thing that can get through to the scope is AC voltage. Any DC voltage is blocked out and cannot get into the scope.

• **DC POSITION:** With the switch set to DC, both DC and AC get through to the scope. This is handy if you're trying to watch for any AC current riding on top of DC voltage.



• **GND POSITION:** This switch position grounds the input so you can set the trace line reference. You can choose to set the base line on any horizontal graticule line you wish. Whichever line you choose can be your reference point for zero volts (ground).

If you ever suspect that the ground point has shifted, simply switch back to GND and see if the base line is right on the graticule you originally selected. You don't need to disconnect the probe from the circuit being tested to do this.

If the baseline has shifted you can readjust the VERTICAL POSITION knob for the channel you're using to put the trace back on the line you originally selected. Then switch back to either AC or DC to measure voltage. Just remember which line on the graticule you've chosen as zero.

Let's scope an alternator.

Alternators generate an AC voltage which is changed to DC charging voltage by the alternator positive and negative diodes. But sometimes the diodes spring a leak, and too much AC passes through. This contaminates the DC.

The AC voltage rides on top of the DC and we call it a ripple. The obvious result is a lower than normal charging voltage. We can also get an annoying whine in the radio FM which follows engine RPM. This has been known to drive musicians batty on a long drive. (It never bothered me, but then again I spent too much time in the artillery.)

Our scope will allow us to check both AC and DC output, and diagnose alternator problems. We want the right amount of DC, and as little AC as possible.

To Check Alternator DC:

• Turn the engine OFF

• And the ignition key should be OFF.

• Ground the scope to the negative terminal of the battery.

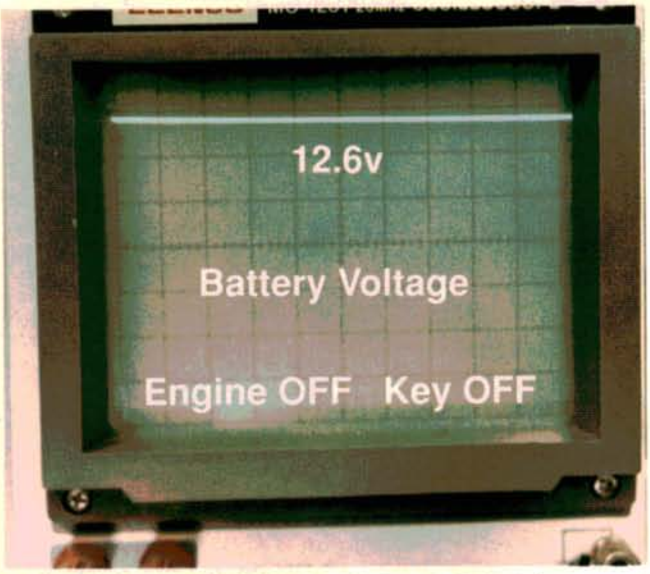
• Hook the test lead from Chan A to the alternator BATT terminal. This is the best point to check for ripple. It's better than the positive post of the battery. Leave the probe switch in the X1 position.

• Set the AC/DC/GND switch to GND and move the scope trace down to the bottom horizontal line of the graticule scale. This line then becomes your ground reference point.

• Adjust the intensity and focus controls for a fine, thin trace line.

• Set Chan A VOLTS/DIV to the 2 volt setting. That makes each main division (or block) equal to 2 volts. (A main division is the distance between lines on the graticule.) The VARIABLE knob (the red knob in the center of the VOLTS/DIV knob) should be turned fully clockwise.

• Set SWEEP TIME/DIV to 1 ms (1 millisecond). This will give us a steady horizontal line with no flickers. (I hate it when the trace flickers.)



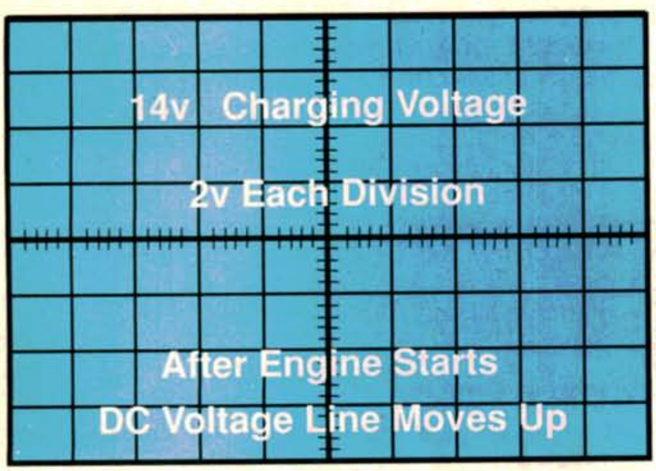
• Set the AC/DC/GND switch to DC. The trace should read battery voltage (12.6 volts). Since each major division is 2 volts, the trace will move up 6 full divisions plus about one and a half minor divisions. (On the 2 volt scale, each minor division is equal to 2.0 volts divided by each of the 5 minor divisions between graticule lines, or 0.4 volt for each minor division.

We're all set to check alternator DC.

Cranking and Charging

Now crank the engine. The trace will drop down because battery voltage drops while cranking. We'll talk about battery voltage during cranking in a moment. But let's stick with the alternator for now.

As soon as the engine starts, the trace should pop up to charging voltage. Let's say the charging voltage is 14.0 volts. How many graticule lines is that? Right, 7 lines times 2 volts per line is equal to 14.0 volts. Now we're looking at the DC output of the alternator, or charging voltage. If charging voltage is 14.4 volts, our trace will move up one more minor division above the 7th graticule line.



Looking at the AC

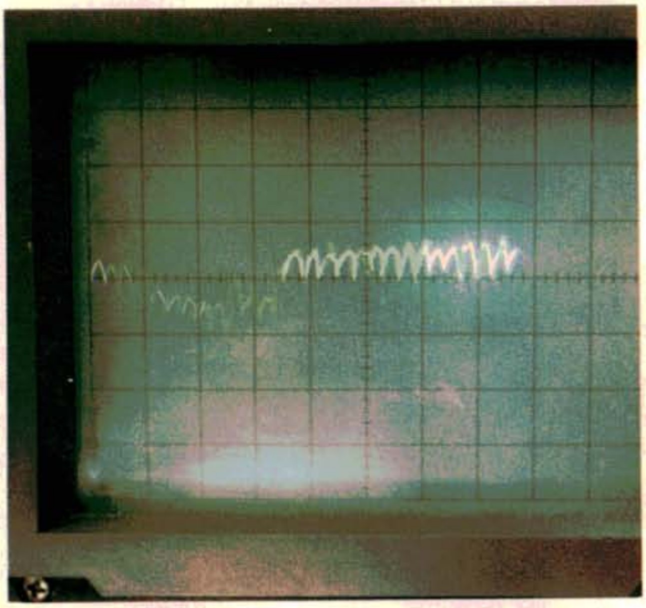
If you switch the AC/GND/DC switch to AC at this time, the trace will drop down to the base line. That's because we've blocked the DC signal to keep it out of the scope. Charging voltage had been holding the trace high, but we eliminated DC voltage by switching to AC.

Before we can take a good look at alternator AC, we need to readjust our scope and use it as a magnifying glass.

To do this, proceed as follows:

• Move the trace to the center graticule line using the VERTICAL POSITION CONTROL.
• Increase magnification by rotating the VOLTS/DIV knob from 2 volts, to 1 volt, to 0.5 volt, and so on. As you continue to rotate the knob clockwise, you'll begin to notice a ripple pattern on the screen.

• Turn on the air conditioner high blower and high beam headlights. This will load the alternator and increase the ripple pattern amplitude even more.
• The ripple pattern waveform is the amount of AC getting out of the alternator. You will see the AC signal of each stator winding as it is excited by the rotor winding. You may want to slow the trace's sweep rate to 5ms or 10ms to take a closer look at the AC pattern.
• How much is too much? Unfortunately that is another one of those questions that can only be answered with experience. Testing known good alternators and keeping track of AC patterns is the best way. If you know a good one, a bad one gets easy to spot.



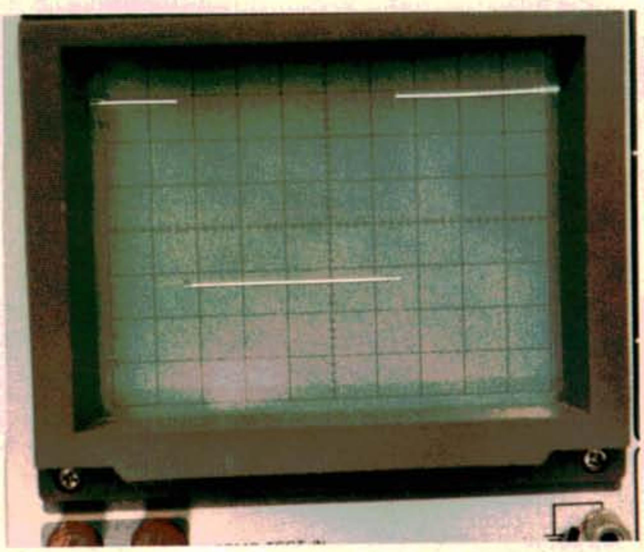
Magnify the Trace So You Can See It

Hall Effect Sender

We can use the same technique to check the Hall Effect sender on this Volkswagen. One wire from the distributor is power, one is ground, and the third wire carries the Hall signal to the Hall Ignition Control Unit. Check the signal with the scope and you'll see a neat square wave signal.

The square wave should have a constant amplitude. Magnify the noise level on the ground side and look at it closely. (Remember, switch to AC input, center the trace on the screen, decrease VOLTS/DIV, and observe the noise level.)

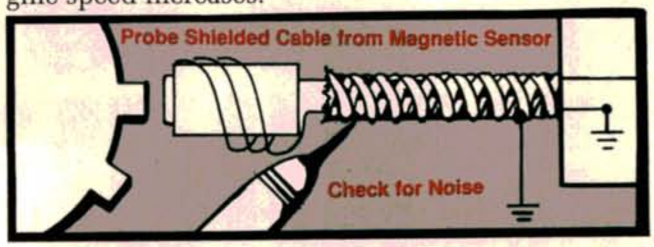
No noise is good noise.



Checking Shielded Cables

Magnetic cam and crank sensors usually have a shielded cable connecting the sensor to the computer. This shielding protects the weak magnetic sensor wave form generated by the sensor from interference caused by stronger noise levels. Scoping the input pins at the ECU will tell you if the sensor is generating a good signal, and if noise levels are acceptably low.

Expect to see a very weak sine wave at idle speed which increases in frequency and amplitude as engine speed increases.



If you find something different from the normal signal, attach the scope probe to the cable shielding, and magnify the image on the scope. Look to see how much noise there is at the shield. If there is too much noise, you may be able to eliminate the worst of it by simply rerouting the shielded cable away from the source of interference (such as secondary ignition wires).

Occasionally, you'll run into a damaged shield ground connection. In this case, repairing the shield's ground may be the answer. ***Note:*** *The shield is only grounded at one end. Listen in with the scope as you reposition or repair the shield to get the noise levels as low as possible.*

Looking for Electrical Noise

Electrical noise can drive computers crazy. The only way to see noise is with a scope, and we just showed you how to do it. The ripple content in the charging voltage has the same effect on a circuit as a dirty or loose connection does.

The scope lets us magnify the trace line. We can make it big enough to watch the noise riding on any wire in the car. Use this technique when you look for circuits with electrical noise.

Here are some examples:

- **Check voltage input leads, both battery and ignition inputs for noise level.** Expect to see no more noise than the amount you normally get from a good alternator on this type of vehicle.
- **Check all computer ground wires for noise.** On many cars, you can see a little pip on the ground side of the computer every time the injectors fire. Once again, practice will tell you what looks normal.
- **Check all computer analog sensor inputs for noise.**

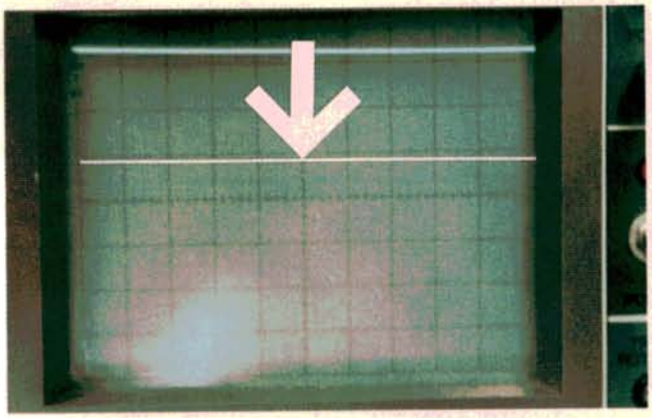
Checking Battery Cranking Voltage

Have you ever tried to check the drop in battery voltage with a DVOM while cranking the car, only to have the car start before the DVOM could lock onto the lowest battery voltage reading? Yes?

But you're probably thinking, "Who cares what the battery cranking voltage is if the car starts?"

You're right, except that the customer has complained to you that at times the car cranks so slowly he's afraid it won't start. In this case, you need to know how low the battery voltage dips as a part of your overall diagnosis.

Set up the scope as you did for the first tests, but instead of probing the BATT terminal on the alternator, probe the positive battery terminal post. Count up from the base line graticule to a point representing 9.6 volts DC, and make a mark with a grease pen.



While cranking the engine, the trace will drop as battery voltage decreases. It shouldn't touch your mark at 9.6 volts.

Finding Time

There are times when we almost want to apologize for asking you to keep checking "known good" patterns as a guide to recognizing bad patterns. You may be thinking, "I don't have the time to keep dragging that thing out and hooking it up."

Maybe this will help. An engineer from one of the OEs was telling me that they had experienced a rash of problems with cruise control failures. Using recommended methods and a DVOM, their dealership techs were stumped, until one of them checked the square wave being sent by the speed sensor in the instrument cluster.

Instead of a nice crisp square wave, the voltage peaks looked like the foothills of the Appalachians. The voltage amplitude was correct, but the form of the signal was gibberish to the control unit. At first the manufacturer was reluctant to believe that all the senders were bad, but scope testing of their own proved the point.

Sometimes a DVOM isn't enough.

—By Vince Fischelli