



Test Bench



Sun Machine 400

Here Comes The Sun

W

hile working for the past three years on the tech line at Automotive Information Systems, I found that a great number of the automotive technicians I assisted were using computers in their shops as well as at home. Their shop computers were used for managing customer repair orders, CD-ROM based automotive information systems such as ALLDATA, Mitchell ON DEMAND, or Shop Key, and for storing waveforms and repair procedures. I would venture to guess that more than 70 percent of independent repair shops are using PCs for multiple shop needs.

PCs are making the never-ending changes in the automotive industry a lot easier to bear. Can you imagine the room it would take to store enough written material such as shop manuals, wiring diagrams, and spec booklets to work on all makes and models from bumper to bumper, not to mention the cost?

Another way in which PCs are being used is to collect automotive data for diagnostic purposes. Data acquisition can be used to collect the information needed for the PC to display lab scope patterns, ignition scope patterns, and gas emissions, just to name a few. Data acquisition makes it possible for the PC to become an oscilloscope, emission analyzer, and DVOM as well as take the place of other diagnostic tools. The data acquisition device converts analog signal such as the inductive voltage from a plug wire into a useable binary input to the computer. Customized software uses this digitized information to display the waveforms.

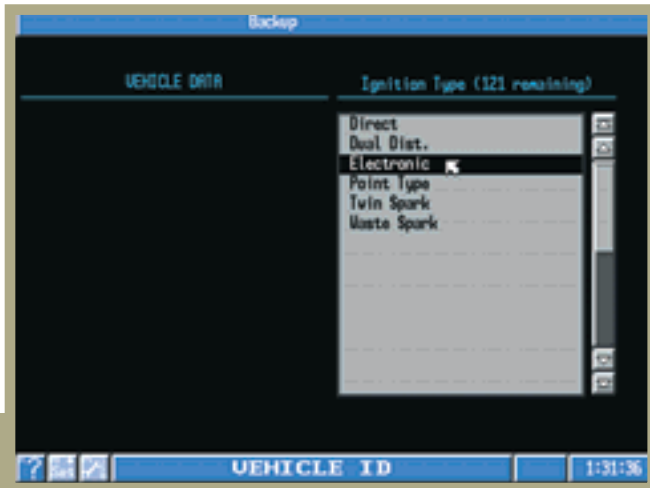


Figure 1 Vehicle ID Menu



Figure 2 DC Volts Display

This Month's Subject

The Sun Machine 400 was Sun Electric's first PC based engine analyzer. It is a fully operational modern Pentium-based PC with the data acquisition capability and software to display a great deal of automotive diagnostic information. The Sun Machine 400's customized software runs on a user-friendly Windows 95 operating system. Unlike earlier PC-based engine analyzer software, there is no C:\> to deal with.

The most important issue when buying an expensive new tool is its forward compatibility with the latest and greatest upgrades and add-ons. While the Sun Machine 400 is equipped with the hardware necessary to run both Windows 95 and the customized Sun Machine 400 software, it can easily be upgraded to run whatever Windows 95 application you wish to use. The analyzer's computer is equipped with a standardized Pentium Socket 7 mainboard, Intel Pentium 133 MHz CPU, 16 MB of fast EDO RAM, 2.1 GB IDE hard drive, 16x or higher IDE CD-ROM, and 2 MB SVGA card. Upgrades can be accomplished using standard PC components. No OEM-specific hardware is employed. Add-ons such as SIMU-TECH, Shop Key, and the Snap-On Scanner can also be easily installed.

The Sun Machine 400 also has optional accessories such as a fax/modem, 15" or 17" SVGA monitor, printer, extra CD-ROM drives and hard drives, timing advance light, vacuum probe, power balance probe, SIMU-TECH pod holder, remote control kit, five gas kit, and high and low amps probes.

How It Works

Using the Sun Machine 400 is as simple as turning on the machine and clicking the program icon located on the Windows 95 desktop. The main menu then opens,

consisting of Vehicle ID, Cranking/Compression, Multimeter, Engine Data, Scope, Dynamic kV, Emissions Digital, Emissions Graphic, Cyl. Shorting, Rapid Power Balance, Utilities, and Calibration.

Vehicle ID (Figure 1) allows the user to select the type of ignition that the vehicle has as well as the number of cylinders and the firing order. This information is needed for engine RPM calculation and cylinder identification. Selecting the wrong ignition type can cause an incorrect engine RPM to be displayed.

For instance, selecting Direct tells the program that you are working on a vehicle with a Direct ignition system that fires once per cylinder in respect to one rotation of the camshaft. The program determines one rotation of the camshaft by the number of cylinders selected and the ignition type. Selecting Waste Spark tells the program that you are working on a system that fires two times per cylinder in respect to one rotation of the camshaft, one of which is waste. Selecting Direct for a vehicle using waste spark will cause the RPM read out to display approximately twice the true RPM.

After entering the Vehicle ID information, we are ready to select the test function we want to perform from the Main menu and connect the necessary test leads. Selecting the Multimeter test function will open the Multimeter menu which consist of DC Volts, Ohms, Frequency, Duty Cycle, Continuity, and Low Amps.

The DC Volts selection (Figure 2) will set up the display much the same as your DVOM when set to DC volts. You can use this setting to check available DC volts at a given device such as a sensor or solenoid as well as to check for a voltage drops. You can also use the mouse to click "Display" located on the menu bar. This will toggle the DC Volts display from a live digital reading with a minimum and maximum gauge reading to an all digital live, and digital

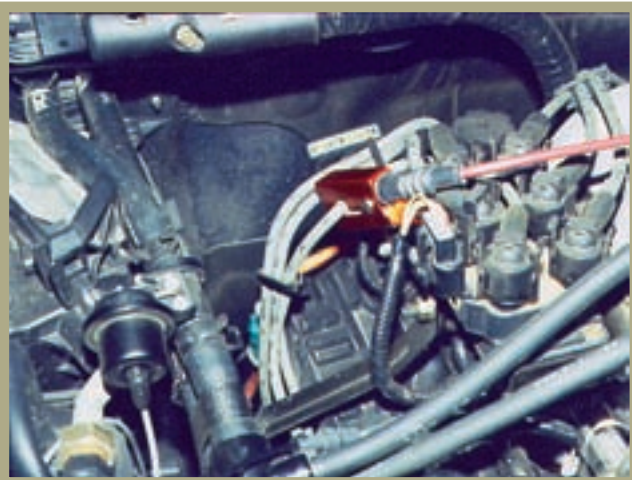


Figure 3 Inductive Ignition Pickup

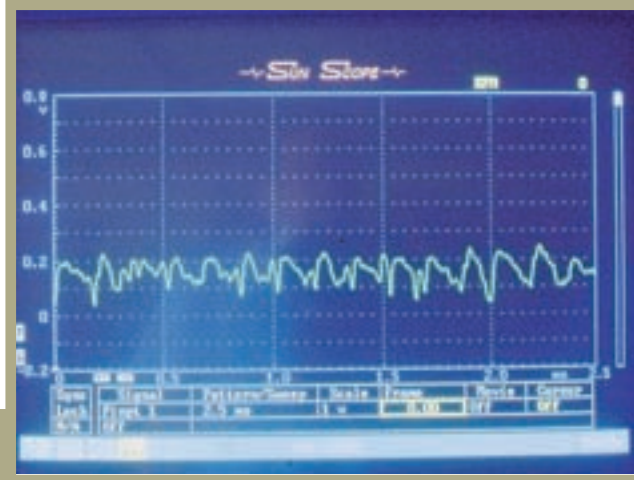


Figure 4 Engine Ground Voltage While Cranking

minimum and maximum reading.

We used the DC Volts selection to check the voltage drop between battery ground and the engine block while cranking the engine. A reading of 250 mV or less while cranking the engine indicates that the engine ground is good. However a voltage drop of more than 250 mV would indicate a poor connection between the battery ground and engine block. A faulty or dragging starter will generally use excessive current, which will also increase the amount of voltage dropped between the battery ground and engine block.

The Scope test function can be used to display a more detailed picture of the voltage drop while cranking the engine. Even though the DC Volts display shows approximately 150-200 mV while cranking the engine, the voltage is constantly increasing and decreasing proportional to the starter's current.

To return to the Main menu just click the right mouse button on the existing screen (in this case the DC Volts display). Selecting Scope will bring up the Scope menu items which are Ignition Scope, Lab Scope, Alternator Ripple, Low Amps Probe, High Amps Probe, Vacuum Probe, and Power Balance Probe. For this particular test we will select Lab Scope. When the Lab Scope screen appears, you will have the choice of single or dual trace. Using the dual trace function requires connecting an additional set of leads and setting the voltage and time for the grid at the bottom of the display. For this test we turned off the grid at the bottom of the screen to display a single trace.

Setting the voltage to 1 volt will adjust the grid to display 100 mV per division (the grid is 10 vertical 100 mV divisions). Setting the time to 2.5 mS adjusts the grid to display .5 mS per division (the grid is 5 horizontal .5 mS divisions). By triggering the scope off cylinder 1, the trace starts each time the number 1 cylinder is fired. Using the number 1 cylinder to

trigger the scope also requires that the inductive probe for the number 1 cylinder be clamped around the number 1 spark plug wire (**Figure 3**).

The next step is to disable the fuel pump by disconnecting the fuel pump relay or inertia switch, so the vehicle does not start. While cranking the engine, the display shows a much different voltage than the DVOM. You can see the voltage increase and decrease as the starter's current increases and decreases. Knowing what a good pattern looks like helps when examining a ground problem.

Auto Trigger can be used, instead of triggering off cylinder number 1 to display a constant waveform. The time setting can also be increased to see more time displayed. For instance, with the time set to 2.5 mS, only 2.5 mS of time is displayed across the screen. Setting the time to 500 mS will display 1/2 second of time across the screen with the grid divided into 100 mS divisions.

Even though a DVOM can give you a pretty good idea of how well a ground is connected, using the Lab Scope to check grounds is much more precise. Peak voltages increasing to a greater than normal value when current is at its highest but dropping to approximately zero volts when current decreases, are an indication of a problem. The engine's ground cable may have a connection problem at the engine or battery, or the cable/cable ends may be defective or corroded.

Poor engine grounds can cause a multitude of problems. At no other time is the engine ground challenged as much as when cranking the engine. While the engine is running, the block usually provides ground for such things as the ignition module and PCM inputs which all total less than 15A. The starter on the other hand usually pulls more than 200A to turn an engine. An example of a good engine ground while cranking is shown in **Figure 4**.



Figure 5 Low Current Amp Probe Waveform Of A Saturated Switch-type Injector

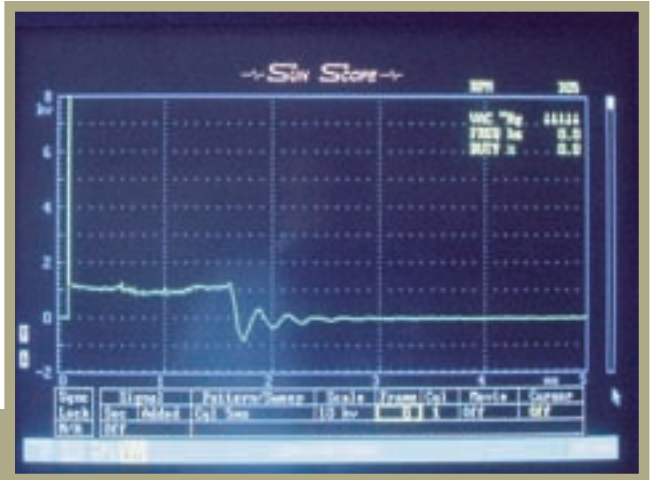


Figure 6 Single Secondary Cylinder Pattern

Other Waveforms

Using the Lab Scope function to examine square waveforms or AC voltage waveforms can be accomplished by setting the voltage, time, trigger, and slope. The dual trace function of the lab scope is useful for dual tracing injector and O₂ sensor waveforms, crankshaft sensor and coil primary waveforms, as well as crankshaft sensor and camshaft sensor waveforms.

The optional Low Current Amp probe makes it possible to view current waveforms for devices such as injectors, ignition coils, and practically any type of solenoid or actuator when used with the scope (Figure 5). This is especially useful for viewing bank injection systems, by allowing one of several injectors connected in parallel to be viewed without disconnecting the others.

The Sun Machine 400 has the ability to freeze or recall a particular section of the waveform frame-by-frame. While the signal is being sampled and displayed, it also is continuously stored in a data buffer as it displays on the screen. The frame-by-frame review can then be used to replay and isolate intermittent anomalies. This is an advantage over the earlier live-scopes. It is also an advantage over most modern hand-held DSOs because the PC's large hard drive means there is a much larger amount of memory (storage space) available for recording the patterns.

Secondary Ignition

Clicking the right mouse button on the display will close the Lab Scope and bring you back to the Scope menu. To examine a secondary ignition waveform, click the left mouse button on Ignition Scope. The Ignition Scope display looks much like the Lab Scope display, only the voltage range is much higher (kV). Pattern/Sweep can be set to Raster, Raster 5 mS, Parade, Parade 5 mS, Cyl, or Cyl 5 mS (Figure 6).

Time is not adjustable in the Ignition Scope. Everything is preset per Pattern/Sweep selection, except for voltage and trigger. Both voltage and trigger have a default setting, but can be adjusted to better view the waveform. It is also possible to view both raster and parade at the same time (Figure 7).

The Dynamic kV selection (Figure 8 on next page) is used to monitor live secondary ignition for both distributor and distributorless ignition systems. The display is first sampled and then stored, so the display is not truly live, but the sampling and displaying rate is fast enough to make the digital display very close to being a live display. You can choose from multiple screens to view the waveforms, depending on the type of ignition system being tested and the format selected. Live firing kV, spark kV, and kV duration displays are available in either bar graph or numeric format. Coil oscillations are displayed on the numeric screen as well. Special features such as displays for Added mode, Power mode, Waste mode, and Power/Waste combination are added for distributorless ignition diagnostics.

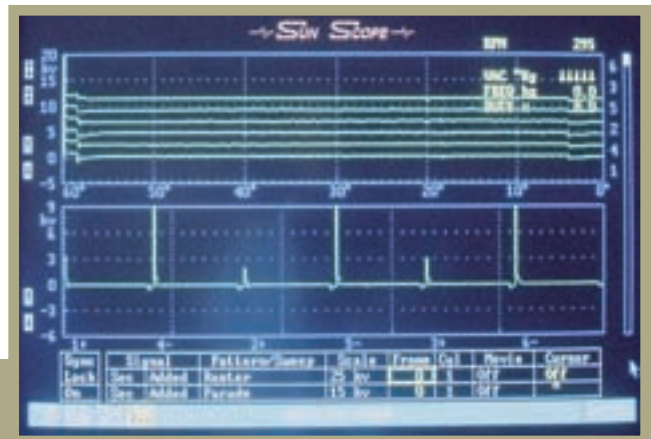
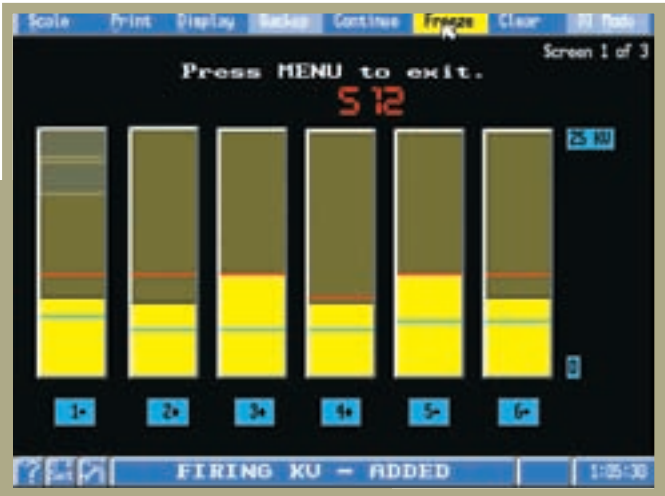


Figure 7 Raster and Parade Dual Trace Waveforms

Figure 8
Dynamic KV



Exhaust Gas Analyzer

The four gas analyzer is yet another useful feature of the 400. The four gas analyzer displays RPM, vacuum (HG), HC ppm, CO in percentage, O₂ in percentage, CO₂ in percentage, Air/Fuel ratio, and has a calibrated Flow indicator as well. Upgrading to five gas to monitor NO_x is optional. Selecting Emissions Digital from the main menu opens the live four gas display (**Figure 9**). The Min data format gives a quick review of live readings. The Max data format is used to review all of the live values captured, including lowest and highest, and to determine how much the readings vary.

The four gas analyzer is very useful for testing converter operations. While a two gas analyzer will measure HC and CO, the catalytic converter reduces these emissions to levels that are almost impossible to measure at the tailpipe. If a two gas analyzer shows that HC and CO emissions are greater than they should be, it could be the result of a fuel problem, ignition problem or converter problem. Further testing is then necessary to isolate the cause.

The four gas analyzer provides CO₂ and O₂ readings that along with the HC and CO readings are a more accurate indication of converter efficiency. At idle the percentage of CO₂ should be

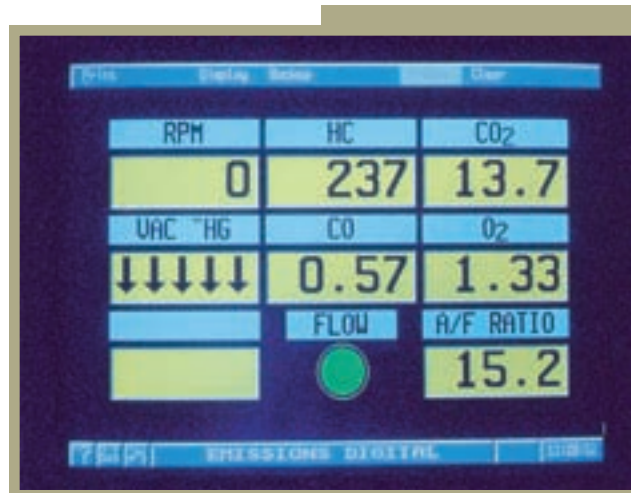


Figure 9
Four Gas Display

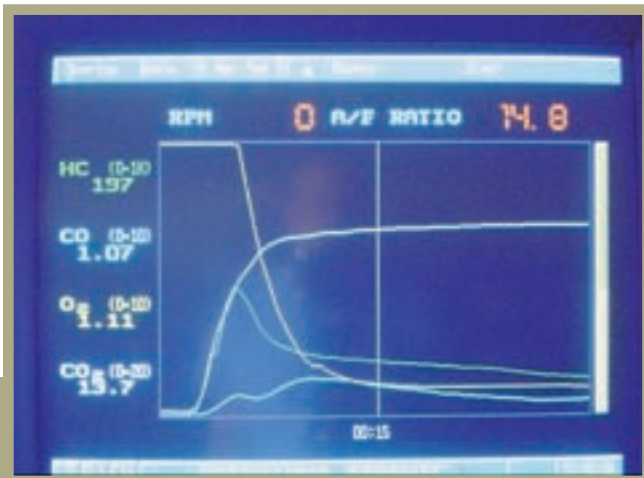


Figure 10 Emission Graph Display

quite high, approximately 13-15 percent and O₂ should be very low, usually 1-2 percent. In addition the combined percentage of CO and CO₂ should equal an

approximate 14.7 percent with an air/fuel ratio of 14.7 to 1. If the engine is running lean, O₂ increases and CO₂ decreases while the combined percentage of CO and CO₂ decreases. If the engine is running slightly rich, O₂ decreases and CO₂ increases with the combine percentage of CO and CO₂ increasing, however an extreme rich condition will again lower CO₂.

Emission Graphing Capability

The Sun Machine 400 has the ability to graph HC, CO, CO₂, and O₂ over a period of time, as well as display live readings (Figure 10). It will also graph NO_x with the addition of the five gas module. Graphing the tailpipe emission can prove useful for viewing emissions under load if a chassis dynamometer is available.

Engine Data

The Engine Data test function (Figure 11) will display the result of several diagnostic test functions at once. This can be helpful when waiting for an intermittent problem to occur. The displayed parameters are RPM, Dwell, Coil⁺, Coil⁻, Charging/Battery voltage, Alternator Ripple, Duty Cycle, Ignition Timing, Manifold Vacuum, Alternator current output, four gas emissions, air/fuel ratio.



Figure 11 Engine Data

Summary

I found the Sun Machine 400 to be very useful for many reasons. Not only does it provide the necessary engine performance diagnostic tools, but it can also be upgraded by adding any additional diagnostic equipment that may be needed in the future.

I have described the Sun Machine 400's major capabilities here. If you would like more information about this piece of equipment, contact your Snap-On/Sun representative, or **Circle No. 139** on the Reader Service Card.

—By Mitch Belew
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