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Editor

"G" Jerry Truglia

"Labscope Tidbits"

An oscilloscope, labscope, or scope for short, is a voltmeter that captures many voltage samples and then graphs them on a screen. Voltage appears as a trace of light that moves up and down and across the screen to indicate circuit voltage trends. The scope creates a picture of voltage changes as they occur in a circuit over time. It's today's MRI into the vehicle's electrical system and easy to use.

Labscopes either have push buttons or use the mouse or keyboard if they are installed on a computer. These controls allow for voltage, time or trigger changers. The list below shows a range of Volt/Div adjustments we might see on a scope, and the maximum voltage that can be displayed on screen for each setting.

The range of adjustment and individual voltage levels depend on the scope design. The maximum voltage that can be displayed is calculated by multiplying the number of vertical divisions times the voltage setting, e.g. 10 divisions x 10 volts = 100 volts.

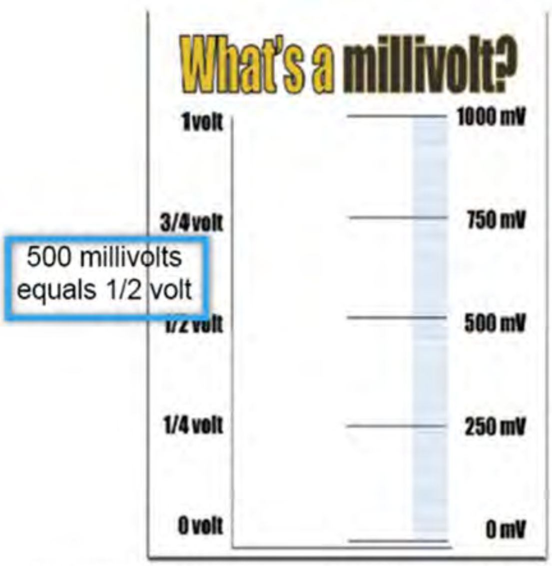
Volt/Div	Maximum Voltage Displayed on Screen
.050 V (50 mV)	400 mV
.1 V (100 mV)	800 mV
.2 V (200 mV)	1.6 V
.5 V (500 mV	4 V
1 V	8V
2 V	16 V
5 V	40 V
10 V	80 V
20 V	160 V
50 V	400 V
100 V	800 V
200 V	1600 V

(Con't on page 2)

"Labscope Tidbits" (con't from p. 2)

VOLTS AND MILLIVOLTS

Scope voltage is displayed in volts and millivolts.
To better understand millivolts, simply cut one volt into 1000 equal pieces. Each piece equals one millivolt.



There are 1000 millivolts in one volt.

Traditional zirconia style oxygen sensors operate in a 0-1 volt range. That's zero to one thousand millivolts! The waveform to the right dithers from approximately 150 mv to 850 mv. Note that this waveform has a high frequency rate that indicates an issue on how the engine is operating.

The waveform below left **(Figure 1)** is from an engine that has a current issue that is displayed in the signature of the waveform.

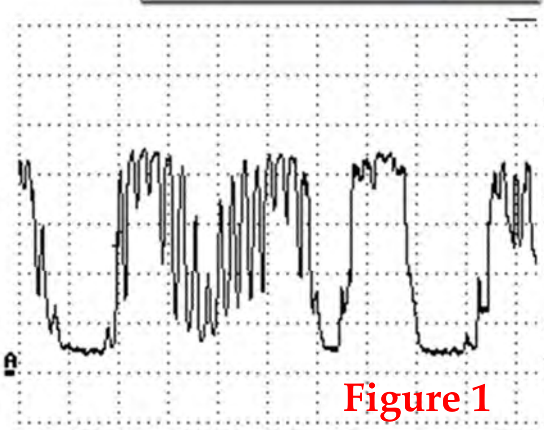


Figure 1

Below **(Figure 2)** is a repetitive waveform of a fuel injector that is displaying more than one signature of the signal. If we count the number of divisions the signal rises, we see that the signal's vertical voltage spike rises 5.5 complete divisions.

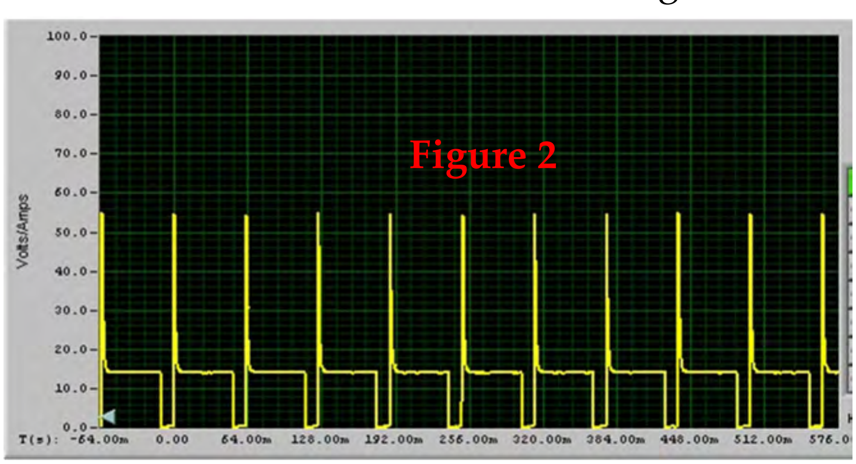


Figure 2

Multiplying volts times the number of divisions tells us the spike's amplitude 5.5 divisions x 10 volts = 55 volts in this instance, a

(Con't on page 6)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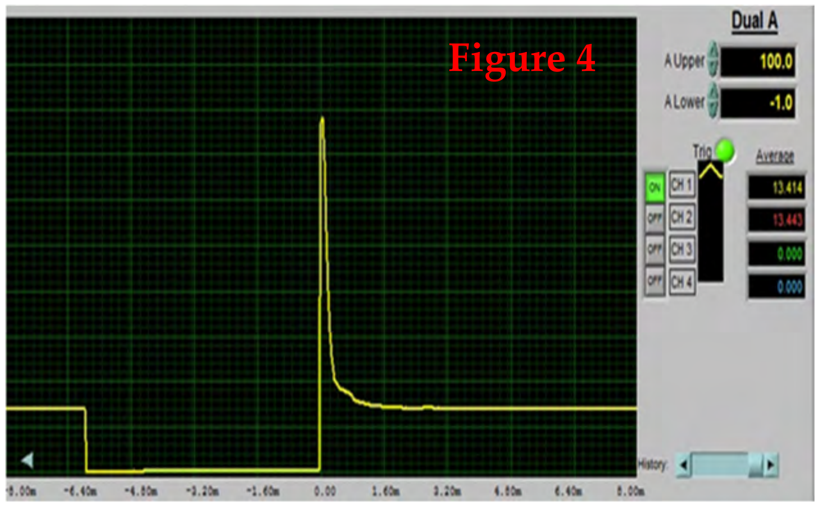
"Labscope Tidbits" (con't from p. 2)

10 volts per division or 100 volts per screen allows us to view the height of the waveform with an amplitude of 55 volts on the screen.

This labscope waveform to the right **(Figure 4)** below is the signature of the signal at the same voltage level. The only difference from this waveform to the one on page 2 is the time that has been selected.



Voltage adjustments allow us to zoom in and out to control how much of a waveform is displayed on screen. The most common voltage settings are 200 mv - 1v - 5 v - 10 v - 20 v per division, or 10 times per screen.

Sometimes we want to zoom in for a closer look at a waveform. It's like putting the waveform under a magnifying glass.

To zoom in, decrease the voltage per division setting.

On page 7 **(Figures 5 & 6)** we are zooming in to take a closer look at part of the fuel injector waveform. The scope voltage is set to 2 Volts/Div. At this setting, we can fit a waveform on screen with a maximum 20 volt amplitude (10 vertical divisions times 2 volts = 20 volts maximum display). Our waveform has an amplitude of 60 volts, however, so approximately 40 volts of the waveform will not fit on screen (unless we increase the Volt/Div setting.) Right now we don't need to see the entire waveform. Instead, we want to zoom in closer to take a look at the ground measurement. This allows us to see the slope from dead zero ground to slightly off ground. If you zoom in further the bottom of the injector ground would resemble

(Con't on page 6)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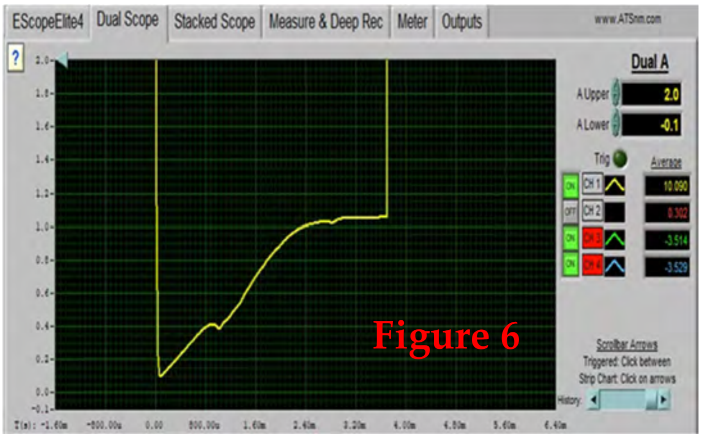
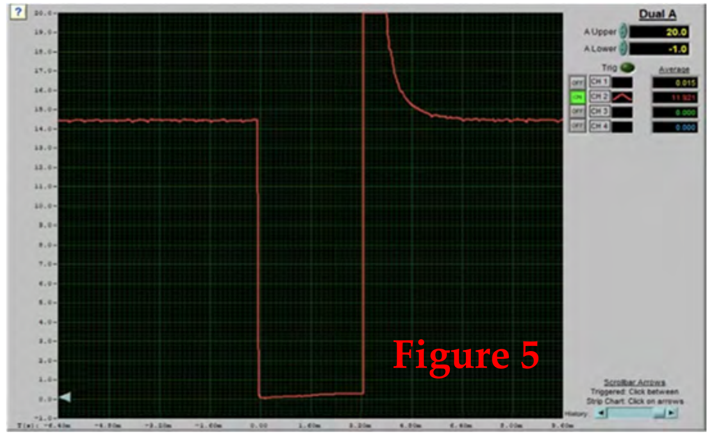
a current waveform as pictured below **(Figure 6)** of an injector.





TIME AND VOLTAGE SETTINGS

Not sure which voltage is the correct voltage to choose for the Volts/Div setting?

Actually, there will always be more than one setting that will get a waveform on screen initially. Once it's on screen, the scope settings can be tweaked to improve the waveform appearance.

SELECTING THE RIGHT VOLTAGE SETTINGS

Here are some sample voltage setting starting points for common measurements:

• Battery and system voltage (2 Volts/Div) • Any sensor operating on a 5 volt reference voltage (1 or 2 Volts/Div) (examples include ECT, MAP, MAF, TPS, photo-optic, many Hall effect sensors, various 3-wire position sensors, etc.) • Zirconia oxygen sensors (0.2 Volt/Div).• Magnetic inductive crankshaft sensors (2 Volts/Div AC) • Magnetic ABS wheel speed sensors (1 or 2 Volts/Div AC) • Idle speed control devices operating at system voltage (2 or 5 Volts/Div) • Knock Sensor (.2 volt/Div) • Ignition Coil Primary (10 or 20 Volts/Div) • Fuel Injectors (10 Volts/Div) • Alternator AC Ripple (50 mV AC coupling)

(Con't on page 11)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"Labscope Tidbits" *(con't from p. 8)*

SELECTING THE RIGHT TIME SETTINGS

A good starting time base **(Figure 7)** for many automotive signals is 2 mS/Div (0.002 second per division). For slow changing waveforms like those from the oxygen sensor, TP sensor, and analog MAP sensor, start at 0.2S (200 milliSec-onds/Div).

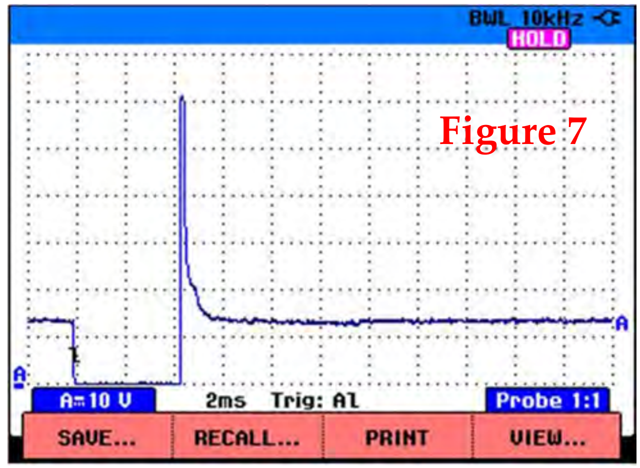

Figure 7

USING AUTO SETUP

Many DSOs take the guesswork out of the initial setup process by sampling the signal, then selecting settings that will display a stable waveform.

This is known as auto setup.

The most obvious advantage to auto setup is that you don't need to remember time and voltage adjustments or set the trigger. The scope gets "something" on the screen and then it's up to you to zoom in or out by making minor adjustments to time and voltage settings.

There are several disadvantages to auto setup:
Auto setup is NOT a good choice if you are hoping to catch a transient event (glitch) since it does not adjust the trigger level out-side the signal's normal voltage range. On Auto Setup the scope automatically chooses a trigger level at 50% of the signal amplitude. The screen shot to the right **(Figure 8)** from Snap On has Auto Find.

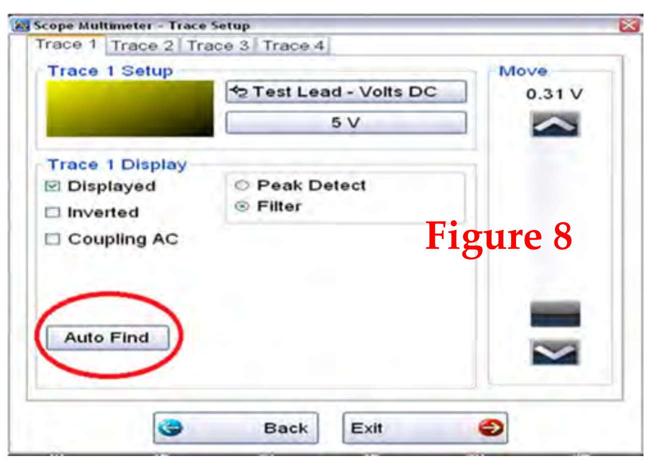

Figure 8

(Con't on page 15)

"Labscope Tidbits" (con't from p. 11)

The scope may assign a default time base for a rather wide range of sampled signal frequencies. If the time base selected is too slow, the waveform may not display correctly.

CURRENT PROBES

A transducer is a device that converts a measurement into a voltage. Transducers commonly measure thing like temperature, pressure, electrical current, and sound. You are probably familiar with a common transducer known as the amp probe. Amp probes **(Figure 9)** convert current measurement (amps) into a calibrated voltage output. Remember, the scope displays only voltage!

Figure 9

High amp current probes are used to measure large load current levels in starting and charging systems.

Our photo shows the amp probe (sometimes referred to as an amp clamp). The probe is connected to the scope input channel, which is adjusted to a low millivolt scale, commonly 50-100 mV/Div. Then the probe is clamped around a main battery cable while the engine is cranked, or around the main alternator B+ wire to measure charging current with the engine running.

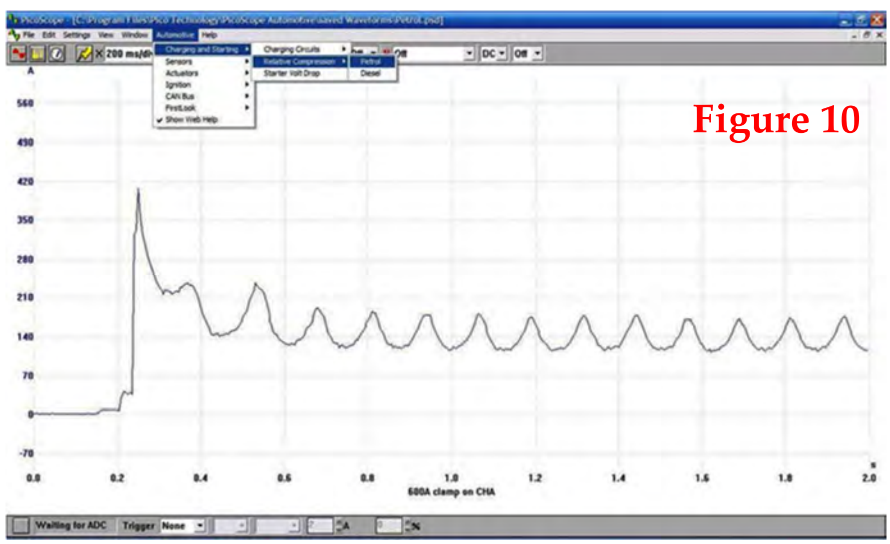

Figure 10

The high initial current (labeled Peak Current) is normal. After the initial surge, the current in the starter circuit falls to a lower, steady level. In this example **(Figure 10)**, initial current falls from a brief initial peak of 400+ amps, to a steady cranking current of approximately 165 amps.

(Con't on page 17)


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"Labscope Tidbits" (con't from p. 15)

Another current measurement accessory is the low amp probe. Its operation is similar to that of the high amp probe; current measurements are converted to a millivoltage that is displayed on a scope as a waveform.

The low amp probe is so named because it is calibrated to measure lower current levels commonly found in fuel injector, fuel pump, blower motor, and ignition coil primary circuits, as well as solenoids and a long list of miscellaneous electrical components.

Figure 11

Low amps probes are faster and easier to use than conventional ammeters. To connect a conventional ammeter, the circuit must be physically opened so the ammeter can be connected in series. The amp probe, however, simply clamps around a circuit wire.

This Fluke 80i-10 low amp probe **(Figure 11)** above has an ON/OFF switch setting and two input levels for low and high resolution measurements. Like the high amp probe, each 10 millivolt or 100 millivolt change in the low amp probe represents one ampere. The low amp probe is accurate to very low current measurements, including milliamperage readings associated with key-off battery drains.

The low amp probe has opened an entirely new area of automotive diagnostics by allowing technicians to view current waveforms of components and circuits as they operate. Dynamic "pictures" of circuit current identify many problems that are harder to detect using only voltage and resistance measurements.

Figure 12

The yellow amp clamp to the right **(Figure 12)** is the Fluke i30s that is the BEST amp clamp to use because the size of the jaw that fit around the battery cables. The specification on the DC range is 30 mA to 30 A with dead on accuracy. There is no problem using this on any vehicle for parasitic / key-off battery drains.

(Con't on page 20)


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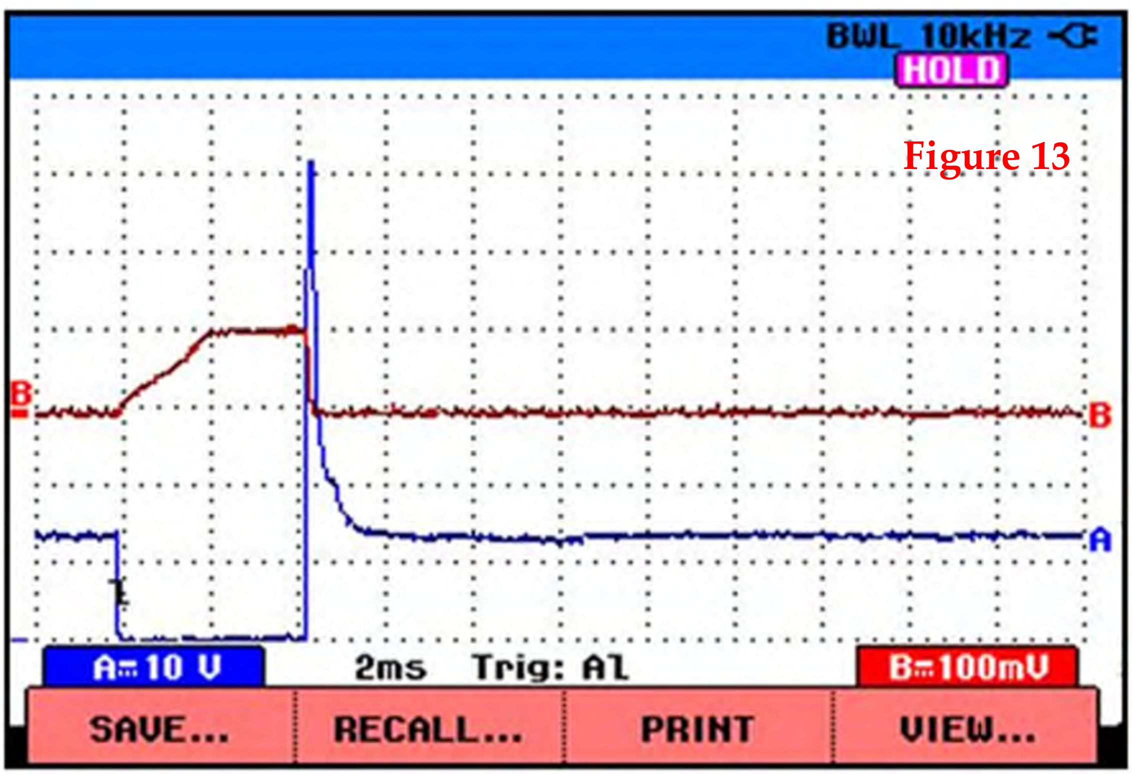
"Labscope Tidbits" (con't from p. 17)

COMBINING VOLTAGE PROBES AND CURRENT PROBES

If we connect one scope channel to a fuel injector using a conventional voltage probe, and then connect the other channel to the same injector with a low amp probe, the scope will display voltage and current — at the same time. The dual trace display lets us compare injector circuit voltage and current.

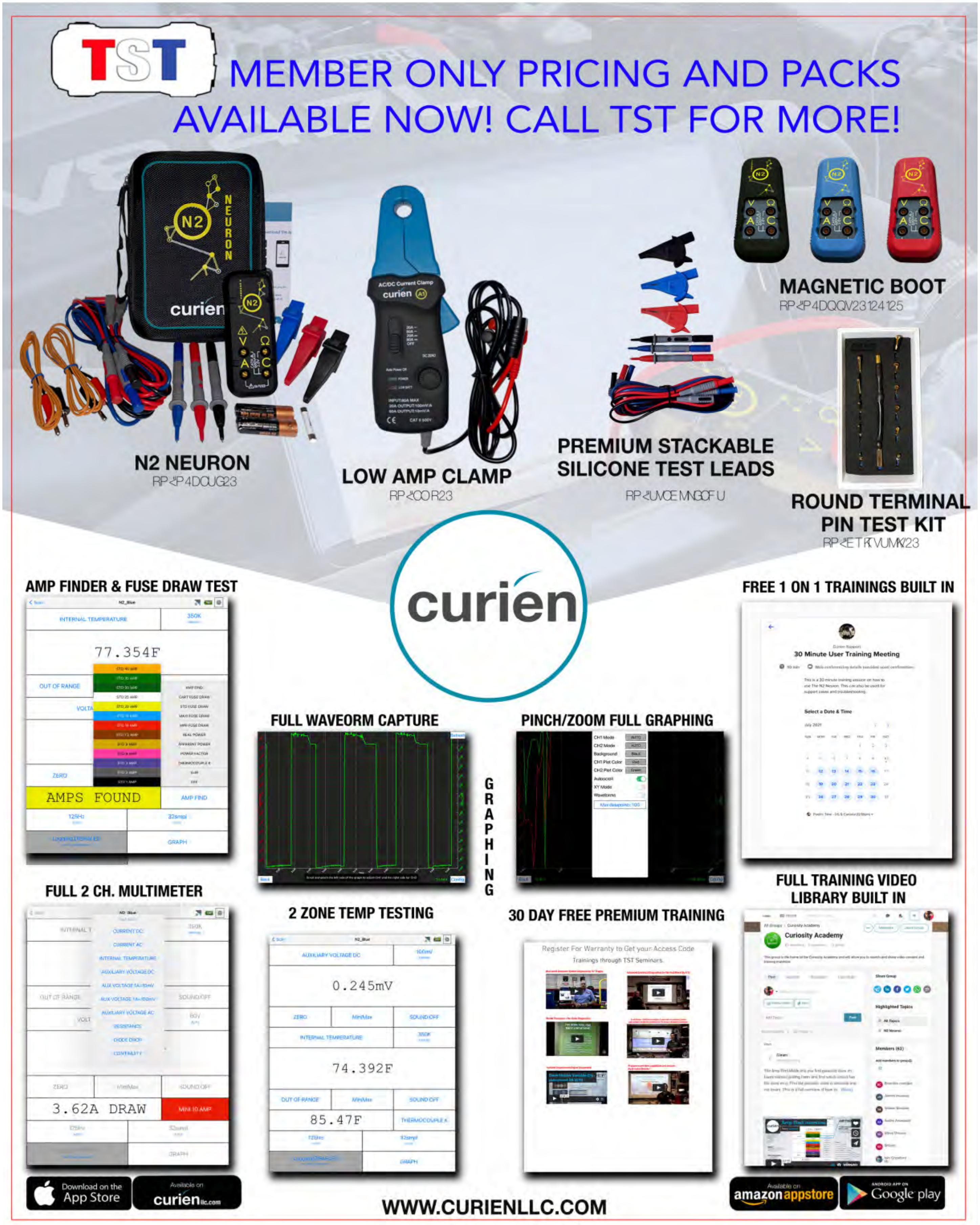
• Voltage waveforms help us identify common injector circuit problems including low supply voltage, faulty switching, weak grounds, etc.

- Current waveforms display circuit current, important when we suspect a problem such as a shorted injector winding, poor computer grounding, or low supply voltage.



The waveform to the right **(Figure 13)** is a good example as voltage falls from it's higher level of about 13 volts to ground on the blue voltage waveform. Notice on the red amperage waveform the current goes up as the voltage went down. This is exactly the similar to a starter motor cranking and engine over. The 12 plus volts would go down a couple of volts as the engine was cranked over and amperage would rise from zero amperes to approximately 150 amps.

(Con't on page 25)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Volume 19, Issue 4

"Labscope Tidbits" (con't from p. 20)

Pressure transducers **(Figure 14)** convert pressure and/or vacuum readings into a voltage signal displayed on the scope as a waveform. The pressure/vacuum transducer plugs into the scope. A hose from the transducer is then connected to a fuel line, transmission fluid line, engine oil line, manifold vacuum nipple, or any other pressure/ vacuum source.

Figure 14

Like the amp probe, the transducer converts the measured pressure or vacuum into a voltage that is then displayed on the scope screen.

Here the scope displays an analog intake manifold pressure sensor waveform, providing us with diagnostic detail not available from a DMM measuring MAP sensor average voltage.

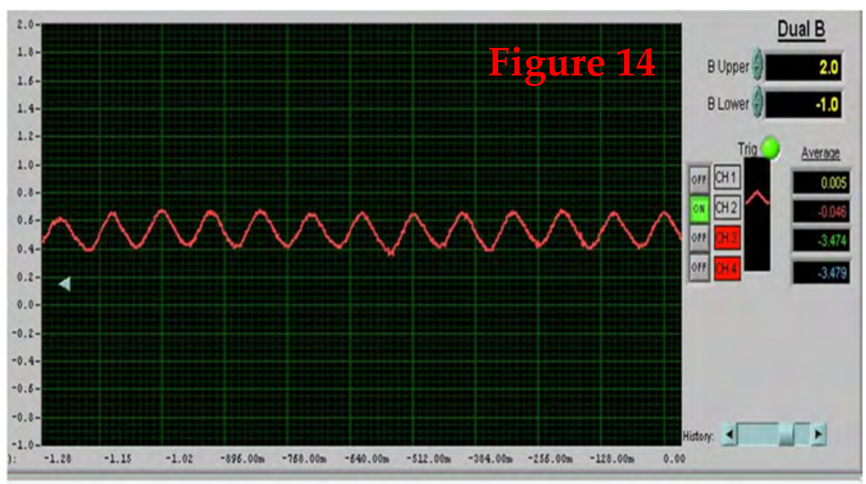

Figure 14

This scope waveform above is displaying a waveform showing pressure pulses inside the intake manifold in a running engine. Even if you aren't sure how to interpret the waveform, you can see that the waves have a consistent general shape and amplitude, indicating a good cranking vacuum on a good engine.

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