))) *FirstLook*™

User's Guide

FirstLook Automotive Engine Diagnostic Sensor
"The Pulse of Your Engine"

Model ADS ES 100

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))) *FirstLook™* Automotive Engine Diagnostic Sensor
"The Pulse of Your Engine"

1. Introduction
Congratulations on your purchase of the *FirstLook*™ automotive engine diagnostic sensor. This is your first step down a road of easier and more accurate engine diagnostics. With *FirstLook* you can now have a more complete picture of an engine's performance, quickly and easily. Once you have learned to use the sensor combined with the timing chart you will be able to find burnt valves, bad injectors and other engine performance problems without major disassembly of the engine...and in a fraction of the time currently required. Consider how long it may take just to remove spark plugs to perform a compression test on today's engines.

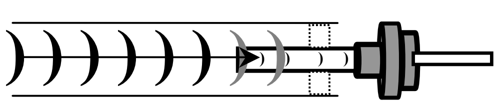
FirstLook is unique because it looks at pulses in engine airflow, allowing you to display "the pulse of your engine" on standard scope equipment. While scanners interrupt the information they receive from engine sensors and engine analyzers tell us what the ignition system is doing, it is difficult to see what is *actually* happening in the engine without intrusive tests. With *FirstLook* in your diagnostic arsenal it will now be possible to see what is dynamically occurring in your engine. Although this user's guide will focus on automobile combustion engines, the FirstLook sensor may also be used with other gasoline and diesel four stroke engines.

2. Overview
Please take a few minutes to become familiar with the many capabilities of FirstLook. A few minutes now will help you save hours of diagnostic time later. This user's guide is divided into the following sections.

- Theory and Operation
- Sensor Setup
- Lab Scope Basics
- Triggered Tests
- Timing Chart Interpretations
- Waveform Analysis

3. Theory of Operation
The FirstLook sensor looks at the airflow pulses generated by the normal operation of internal combustion engine as shown in Figure 1.

Exhaust or Vacuum Side of Engine



Output to Lab Scope

Pulses vary over time depending upon the stroke cycle of engine

Figure 1

The sensor detects these pulse waves through either the exhaust or vacuum sides of the engine. All engines produce a predictable pattern of these pulses that can easily be displayed on most commercially available lab scopes when connected to FirstLook. This pulse wave is sensed and the voltage is output for display by the lab scope. Changes or irregularity in this predictable pattern may be traced back to problems in the engine. The pulse wave can also be affected by unburned fuel in the exhaust and this abnormality is also detected and displayed. ***The FirstLook sensor does not require any external source of power, so you never need to purchase or replace batteries***.

4. Sensor Setup

Setup is very straightforward.

1. Remove sensor and cabling from package (Figure 2)
2. Install appropriate cable (25 ft. BNC or 45 in. Banana) to BNC connector on sensor (Cable selection depends upon the lab scope you will be using)
3. Install BNC connector (or banana plug) on other end of cable to your lab scope
4. Lab scope settings will be discussed in the next section

Package Contents

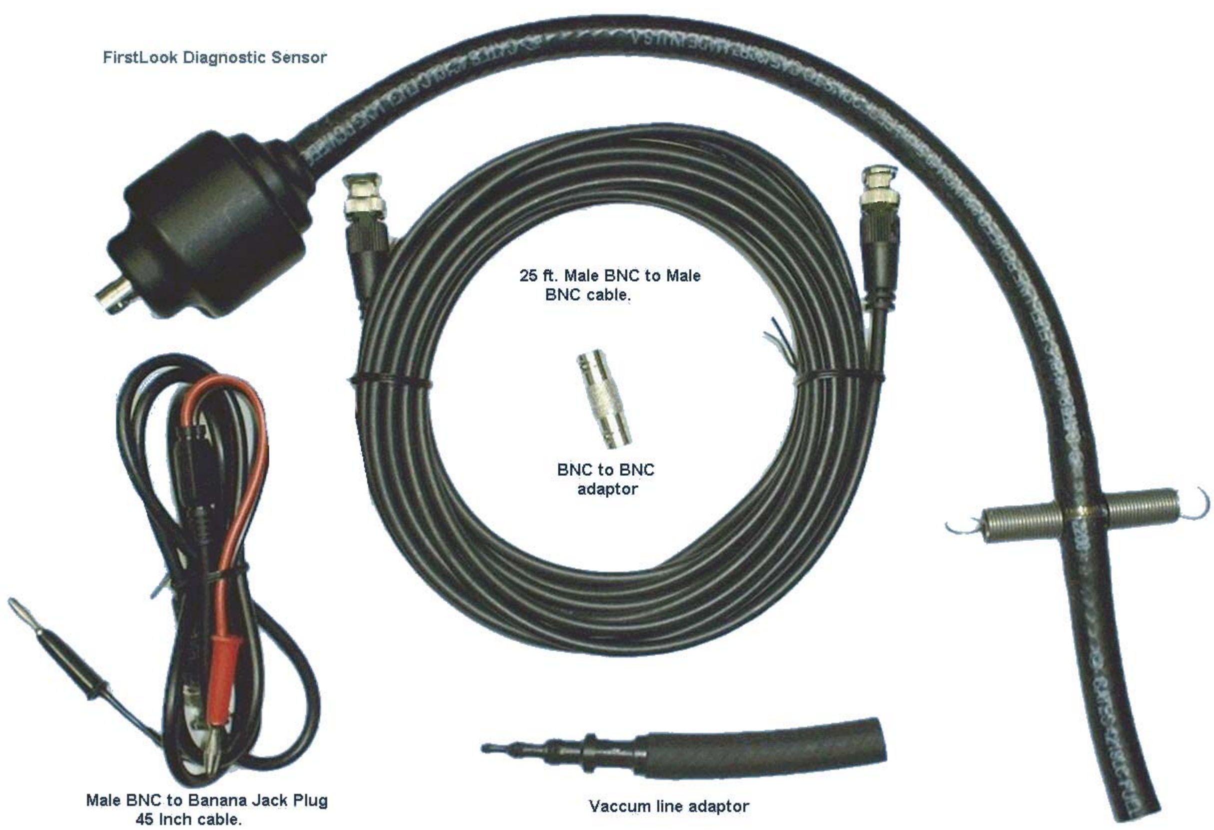


Figure 2

5. ***Lab Scope Basics***

The use of a lab scope allows us to look at how voltage is affected over a period of time. When using the FirstLook sensor the time scale most commonly used will be milliseconds (ms) Voltage scales on the lab scope will typically be in the volts range for sensor readings and in the kilovolts range for ignition triggers. Note that there are "dividers" built into ignition triggers that allow displays in the volts range, even though the actual is kilovolts. Let's take a look at a common lab scope setup in Figure 3.

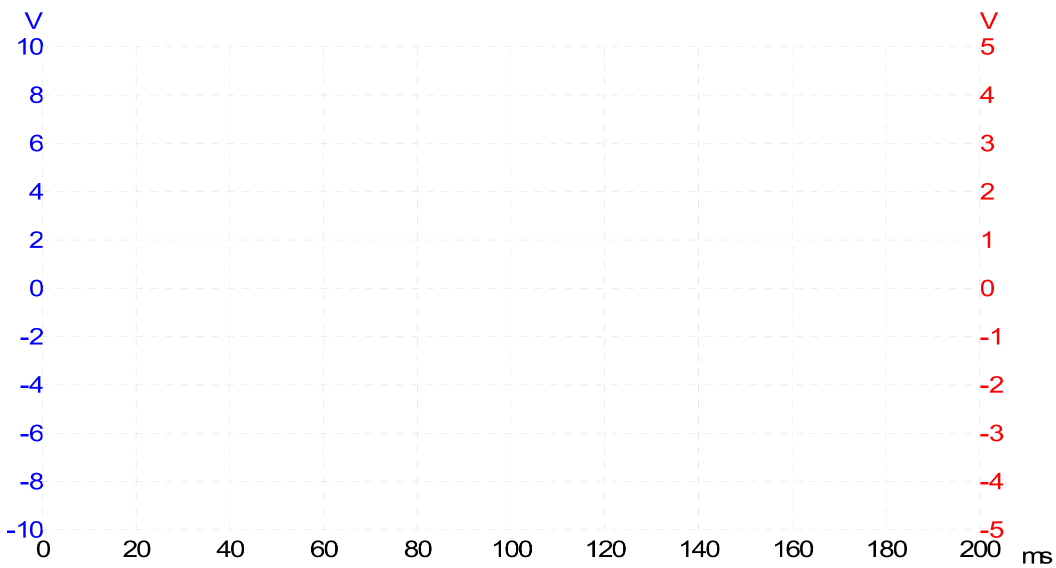


Figure 3

On the left side of the chart we see a vertical number, denoting voltage on Channel 1 (or A) of this lab scope. This is a 10 volt AC scale, and we are looking at equal voltage above and below the zero or center line. On the right we see a 5 volt AC scale on Channel 2 (or B). The voltage shows 2 volts/division on Channel 1, and 1 volt/division on Channel 2. The bottom line on the chart is a time line, in this case 20ms/division. This can also be described as the 200ms scale.

Note that in figure 4 below Channel 1 is set at a 0.5 volts AC scale (0.1volt/division) and Channel 2 is set at a 50mv AC scale (10mv/division). For further lab scope theory refer to your lab scope operation manual.

In this chart we are looking at the actual ignition trigger signal on Channel 1 and the sensor output on Channel 2. By looking at the two signals over the same time base variations in sensor output can be correlated with the ignition trigger reference signal. In combination with the automotive engine timing chart (see Figure 12) specific engine problems can be diagnosed and referenced to a specific cylinder.

Timing reference lines are used to measure differences in time on the signal patterns. In Figure 4 below, these reference lines are labeled "x" and "o" and are placed at specific points on the signal time base. These are shown at the top of the chart and will become important for analyzing patterns with the timing chart.

Reference cursor	x =	133.50 ms
Reference cursor	o =	56.99 ms
Time between reference points	xo =	76.54 ms (difference due to rounding)

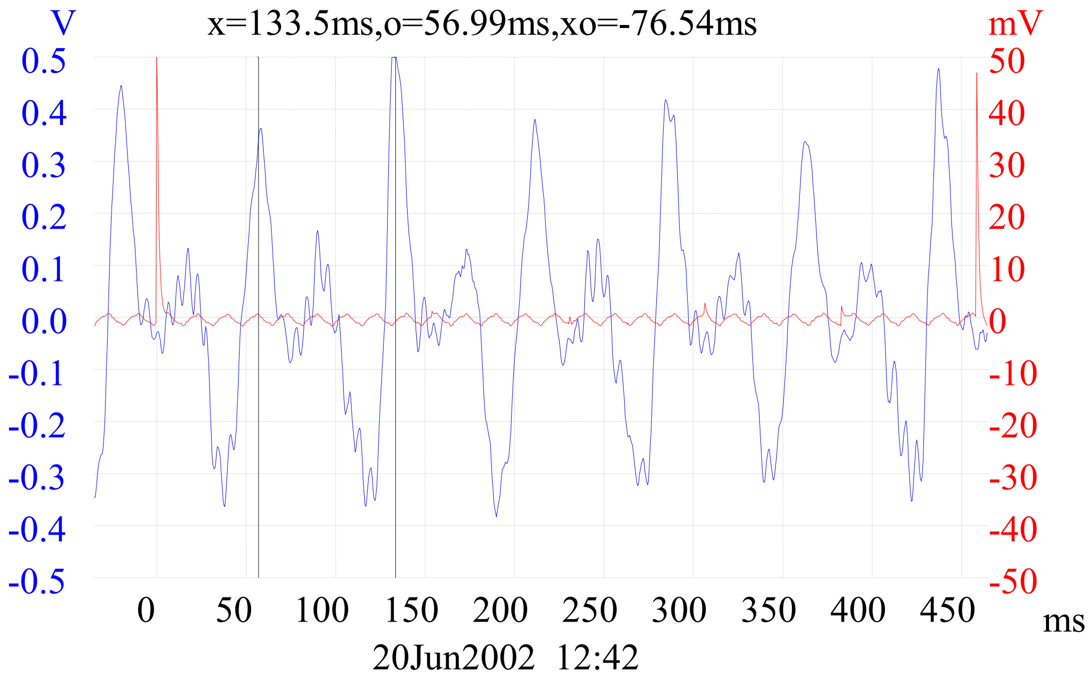


Figure 4

6. ***Automotive Engine Timing Chart***

The timing chart shown in Figure 5 is the key to the diagnostic power behind the FirstLook sensor by correlating the timing of engine events to the visual display. Data is shown for specific cylinder configurations.

- The leftmost column in the chart shows engine speed in Revolutions per Minute (rpm).
- The data in columns **A** to **F** is the time between valve opening events for a given engine with 2 to10 cylinders per 1 Cycle of a 4 stroke engine.
- The next column, Time to Complete 1 Cycle is the total time in milliseconds to complete all firing events in a specific engine at the given rpm. Note that 2 revolutions equal 1 cycle in a 4 stroke engine. This is also the total time window that needs to be open to see the complete firing cycle of all cylinders. If it is necessary to look at multiple cycles, adjust your lab scope to a time base that allows for viewing of multiple cycles of the engine.
- Starting Time Base References are suggested for specific tests in the right most column.

Automotive Engine Timing Chart for Four Cycle Engines

	Time Between Valve Opening Events (milliseconds)							
Engine Speed (rpm)	A 2 Cylinder	B 4 Cylinder	C 5 Cylinder	D 6 Cylinder	E 8 Cylinder	F 10 Cylinder	Time to Complete 1 Cycle in 4 Stroke Engine (ms)	Starting Time Base Reference (ms)
150	400.0	200.0	160.0	133.3	100.0	80.0	800.0	
175	342.9	171.4	137.1	114.3	85.7	68.6	685.7	cold crank
200	300.0	150.0	120.0	100.0	75.0	60.0	600.0	600
225	266.7	133.3	106.7	88.9	66.7	53.3	533.3	
250	240.0	120.0	96.0	80.0	60.0	48.0	480.0	
300	200.0	100.0	80.0	66.7	50.0	40.0	400.0	
350	171.4	85.7	68.6	57.1	42.9	34.3	342.9	
400	150.0	75.0	60.0	50.0	37.5	30.0	300.0	
450	133.3	66.7	53.3	44.4	33.3	26.7	266.7	
500	120.0	60.0	48.0	40.0	30.0	24.0	240.0	
550	109.1	54.5	43.6	36.4	27.3	21.8	218.2	idle start
600	100.0	50.0	40.0	33.3	25.0	20.0	200.0	200
650	92.3	46.2	36.9	30.8	23.1	18.5	184.6	
700	85.7	42.9	34.3	28.6	21.4	17.1	171.4	
750	80.0	40.0	32.0	26.7	20.0	16.0	160.0	
800	75.0	37.5	30.0	25.0	18.8	15.0	150.0	
850	70.6	35.3	28.2	23.5	17.6	14.1	141.2	
900	66.7	33.3	26.7	22.2	16.7	13.3	133.3	
950	63.2	31.6	25.3	21.1	15.8	12.6	126.3	
1000	60.0	30.0	24.0	20.0	15.0	12.0	120.0	
1100	54.5	27.3	21.8	18.2	13.6	10.9	109.1	low rpm
1200	50.0	25.0	20.0	16.7	12.5	10.0	100.0	100
1300	46.2	23.1	18.5	15.4	11.5	9.2	92.3	
1400	42.9	21.4	17.1	14.3	10.7	8.6	85.7	
1500	40.0	20.0	16.0	13.3	10.0	8.0	80.0	
1600	37.5	18.8	15.0	12.5	9.4	7.5	75.0	
1700	35.3	17.6	14.1	11.8	8.8	7.1	70.6	
1800	33.3	16.7	13.3	11.1	8.3	6.7	66.7	
1900	31.6	15.8	12.6	10.5	7.9	6.3	63.2	
2000	30.0	15.0	12.0	10.0	7.5	6.0	60.0	
2100	28.6	14.3	11.4	9.5	7.1	5.7	57.1	
2200	27.3	13.6	10.9	9.1	6.8	5.5	54.5	
2300	26.1	13.0	10.4	8.7	6.5	5.2	52.2	mid range rpm
2400	25.0	12.5	10.0	8.3	6.3	5.0	50.0	50

Figure 5

Let’s take a look at some examples of how to use the timing chart to dissect a waveform.

Figure 6 below shows an idle pattern of a GM 3800 6 cylinder engine with a Firing Order 1-6-5-4-3-2

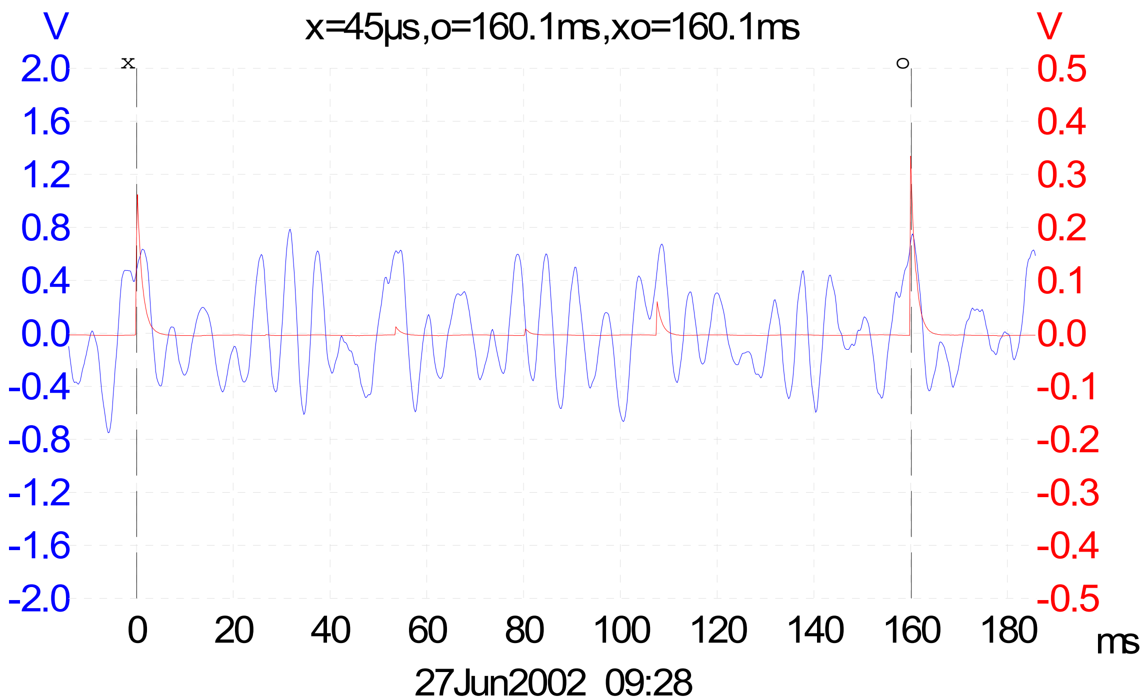


Figure 6

Looking at Figure 6 and the timing chart you can see that with 160ms between firing, or trigger, events the engine rpm is 750. Using the (column D) timing chart in Figure 5 we can also determine that a single cylinder will show up in a 26.7ms window.

IMPORTANT

The sensor signal is delayed in relation to the engine firing order. In other words, the sensor signal has a delay in the exhaust of 1 cylinder for a 4 cylinder engine and 2 cylinders for a 6 or 3 cylinders for 8 cylinder engines. It is important to note that the number 1 plug firing is the event to which we are triggering the display. The cylinder must rotate 180 degrees to begin the exhaust phase of the cycle…this accounts for the offset we see in our display. In the pattern in Figure 11 we see the timing spike at the point the number 1 plug fires. **The result of what happens in the cylinder is not seen until a 180 degree rotation of the crankshaft has taken place and the opening of the exhaust valve occurs. This is seen as an offset to the right of trigger (plug #1) for exhaust readings and as an offset to the left for trigger (plug #1) for vacuum readings.**

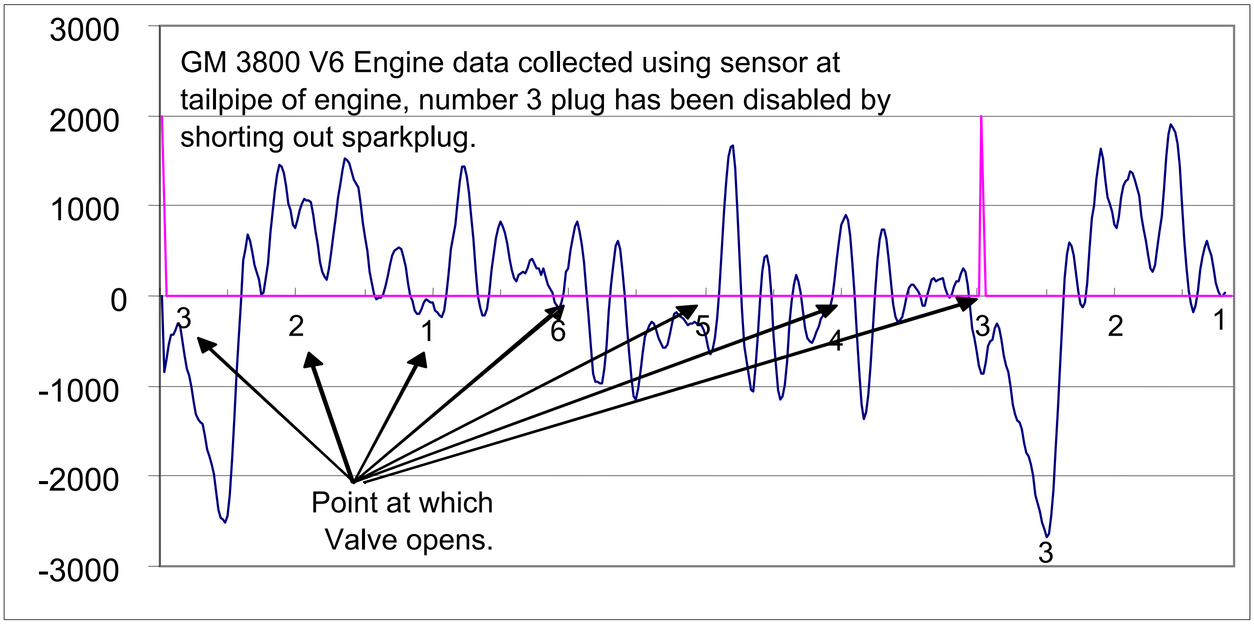


Figure 7

For example in Figure 7 if the engine firing order is 1,6,5,4,3,2 and the trigger is on cylinder #1, then the scope pattern as seen through the exhaust is read as 3,2,1,6,5,4 after taking into account the required cylinder offset.

It is important to note that changes in timing advance, pipe length, and the effects of tuned exhaust will have an impact on waveform outputs. Some waveforms will be almost perfect but others will show the effect of a tuned exhaust system as seen in Figure 7. **Engine problems will always cause a fluctuation of the waveform that extends above or below the average of the other cylinders. This is where comparative analysis of cylinders becomes important. In general the more symmetrical the waveform and distribution above and below the zero reference line, the better the condition of the engine.**

Conditions caused by lack of fuel or lean burn will cause a drop out in the waveform. Problems resulting in excess fuel (dirty injectors, poor combustion, dirty plugs, and plug wire problems) will show up as a drop out in the waveform followed by an increase in waveform above zero as the engine works to compensate for the excess fuel that gets burned in the manifold. (This effect is shown in Figure 14). This is the work of the computer and oxygen sensor in today's engines.

The following charts depict the cylinder offset of 4, 6, and 8 cylinder engines in sensor waveforms obtained through the exhaust pipe of the engine.

Figure 8 shows a Honda Accord 4 cylinder engine as viewed through the exhaust port at idle. This is good example of a clean waveform and ignition timing reference as displayed on a lab scope. The pattern is symmetrical and the amplitude of the waveform is equal above and below the zero reference line. Only minor noise is seen as the engine airflow pulses move through the muffler and catalytic converter. This waveform also shows the slight offset caused by engine advance timing and effect of compressibility and tailpipe length.

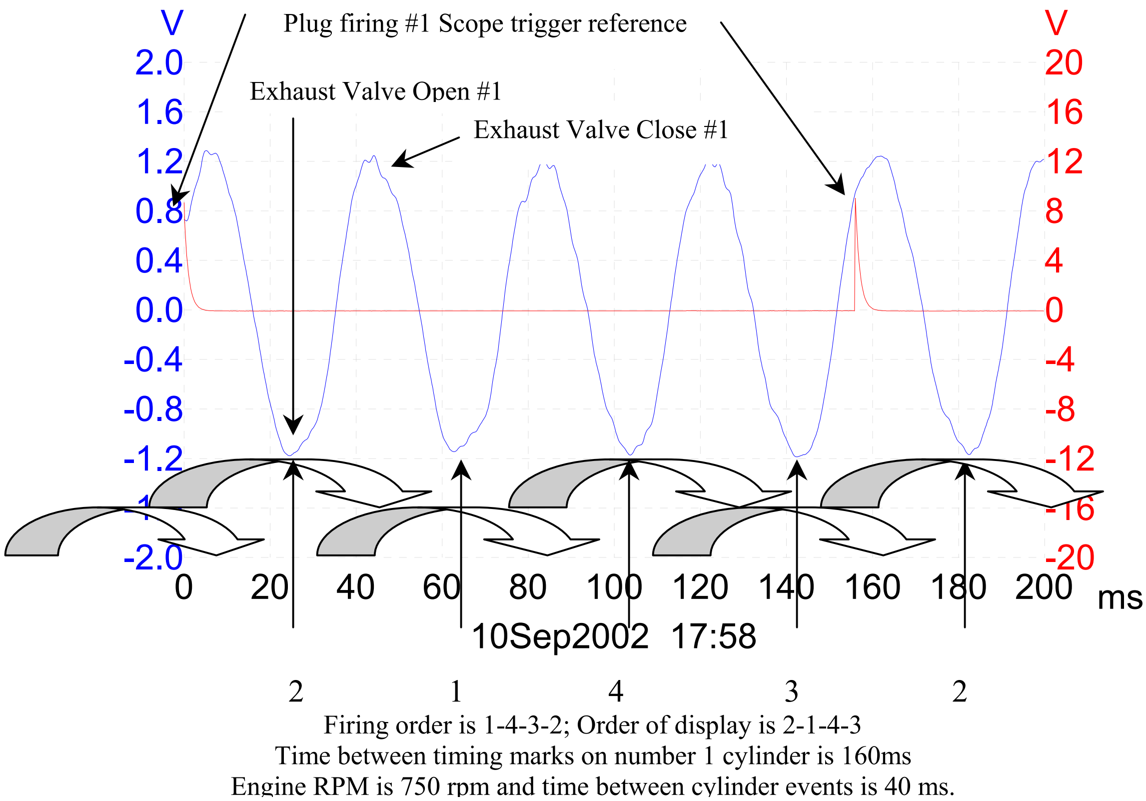


Figure 8

7. ***Triggered tests***

A triggered test allows you to find cylinder specific information by triggering off a repeatable signal generated by engine. Ignition scope triggering can be accomplished in different ways including ignition triggering (most common), current ramping using a low current probe and an injector or coil signal. For the triggered tests described below the trigger will be obtained from the firing provided by cylinder number 1.

It is mandatory that all engine ignition issues are first resolved before running a triggered test. This is because defective or improperly functioning ignition systems can cause trigger problems and potential misdiagnosis. Once all ignition functions are properly resolved, triggered testing can provide highly useful information.

Side note: All tests can be run without a trigger to determine if any engine or fuel related problems exist. However this method does not give cylinder specific information.

Triggered Test #1 - Triggered Cranking Exhaust Test

This test is useful when it is desirable to obtain cylinder specific data without the engine running. Exhaust valve action per cylinder and problems with the head or head gaskets may be assessed. **Do not run this test on a carburated engine.**

To perform this test:

1. Insert sampling hose into exhaust pipe 4 inches
2. Connect ignition trigger from lab scope to cylinder number 1
3. Set time base scale on lab scope to 600ms
4. Set voltage scale for Channel 1 on lab scope to 1v AC
5. Set voltage scale for Channel 2 on lab scope to 5v AC for trigger
6. **DISABLE FUEL SYSTEM (May not be possible on a carburated engine)**
7. Crank engine until display pattern stabilizes
8. Save pattern

Note: Time base and voltage scales shown are recommended starting points for this test. Adjust to achieve best signal display on your lab scope.

Figure 9 shows an example of a triggered cranking pattern as seen through the exhaust

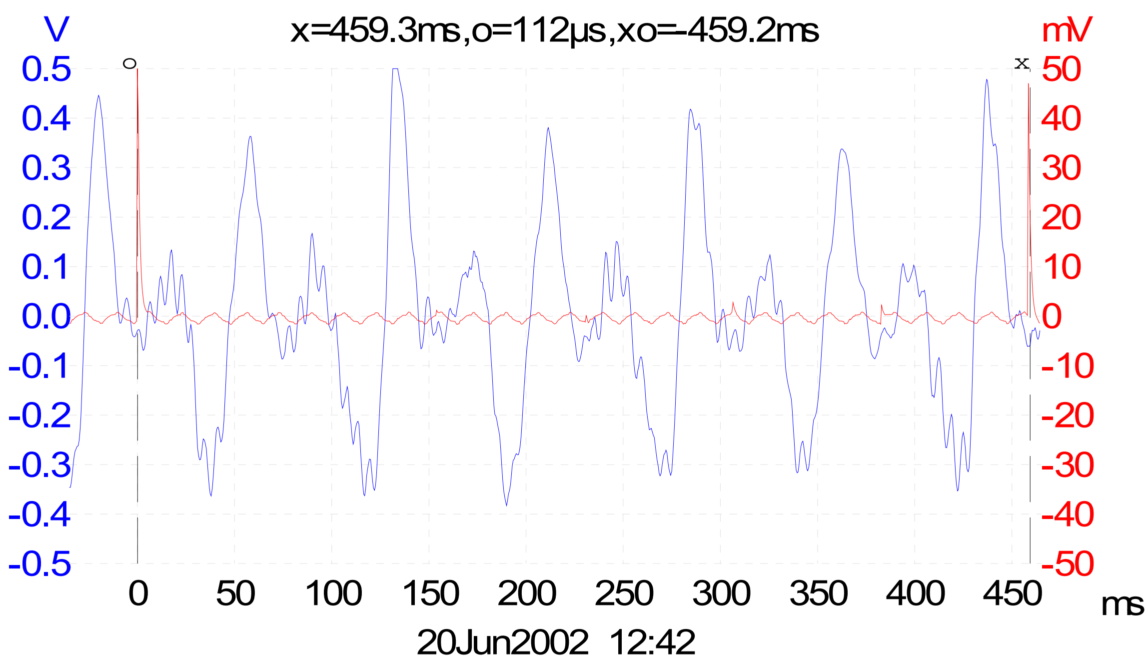


Figure 9

Figure 9 shows a consistent signal pattern on Channel 1 as triggered against Channel 2 on the same time line. Cursor lines are added to show trigger reference (sparkplug #1) and show a 459.2ms time between trigger events. In a later section we will discuss the timing chart and determine that the approximate cranking speed of this engine is 275 rpm.

Triggered Test #2 - Triggered Cranking Vacuum Test from Vacuum Source

This test is useful in the assessment of the intake air and valve system for cylinder specific defects on the intake side of the engine. **Do not run this test on a carburated engine.**

To perform this test:

1. Insert sampling hose onto PCV port, brake booster or best vacuum source
2. Connect ignition trigger from lab scope to cylinder number 1
3. Set time base scale on lab scope to 600ms
4. Set voltage scale for Channel 1 on lab scope to 5v AC
5. Set voltage scale for Channel 2 on lab scope to 5v AC for trigger
6. **DISABLE FUEL SYSTEM (May not be possible on a carburated engine)**
7. Crank engine until display pattern stabilizes
8. Save pattern

Note: Time base and voltage scales are a recommended starting point for this test. Adjust to achieve best signal display on your lab scope.

Figure 10 shows an example of a vacuum pattern as seen from the brake booster vacuum line.

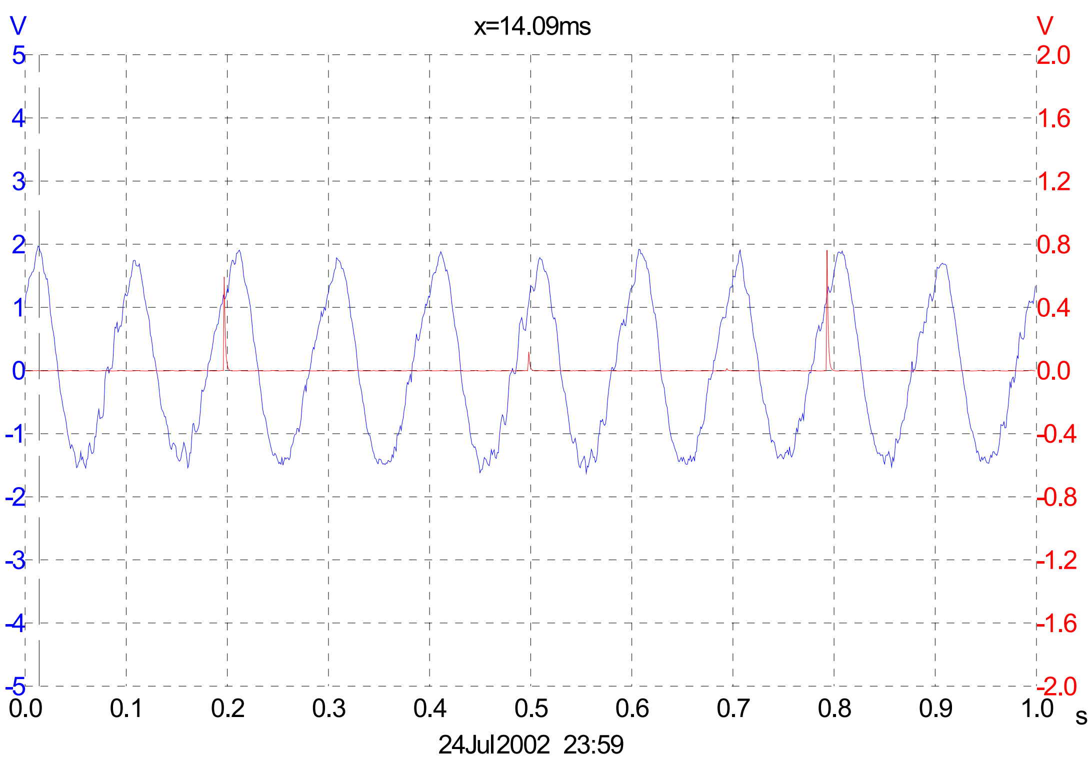


Figure 10

Triggered Test #3 - Engine Idle Test (with a trigger)

This test is useful in the assessing overall engine condition taking into account the fuel delivery system.

To perform this test:

1. Insert sampling hose into exhaust pipe 4 inches
2. Connect ignition trigger from lab scope to cylinder number 1
3. Set time base scale on lab scope to 200ms
4. Set voltage scale for Channel 1 on lab scope to 2v AC
5. Set voltage scale for Channel 2 on lab scope to 5v AC for trigger
6. Start engine and warm up. Allow idle and display pattern to stabilize.
7. Save pattern

Note: Time base and voltage scales are a recommended starting point for this test. Adjust to achieve best signal display on your lab scope.

Figure 11 shows an example of an idle test as seen from the exhaust:

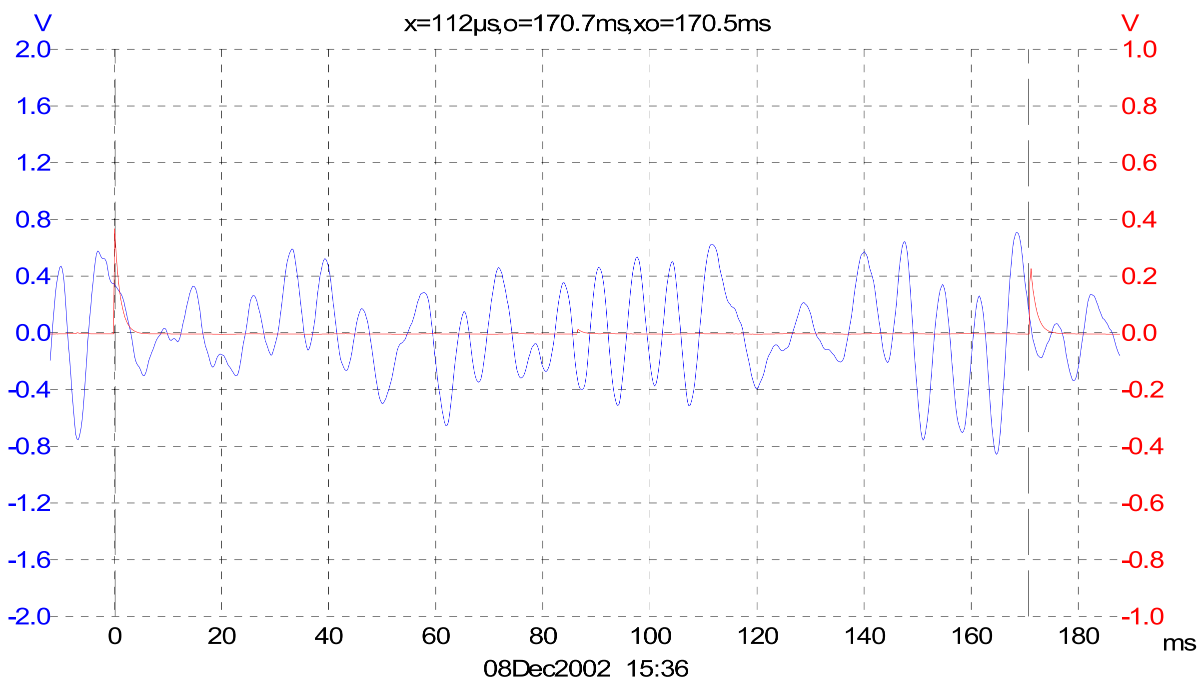


Figure 11

Notice the time between firing events 170.5 ms, this engine is idling at 700 RPM.

Triggered Test #4 - Braked Engine Load Test (with or without a trigger) on exhaust or vacuum

This test is useful in locating intermittent engine problems occurring at higher engine rpm under load on automobiles with automatic transmissions only.

To perform this test:

1. Insert sampling hose into exhaust pipe 4 inches (or attach to PCV port or other vacuum port)
2. Connect ignition trigger from lab scope to cylinder number 1 (optional)
3. Set time base scale on lab scope to 200ms
4. Set voltage scale for Channel 1 on lab scope to 2v AC
5. Set voltage scale for Channel 2 on lab scope to 5v AC for trigger
6. Start engine and warm up. Allow idle and display pattern to stabilize.
7. **SET PARKING BRAKE**
8. **APPLY FOOT PRESSURE ON BRAKE PEDAL**
9. Place transmission in DRIVE
10. Raise engine rpm until problem appears but no higher than 1500 rpm maximum
11. Save pattern
12. Return engine to idle and **place transmission in PARK**

***Important Safety Note*: This test should only be carried out with 2 people. The 1st person should be responsible for running the diagnostic equipment outside the vehicle and the 2nd person for vehicle operation inside the vehicle.**

Note: Time base and voltage scales are a recommended starting point for this test. Adjust to achieve best signal display on your lab scope.

Figure 12 is an example of a braked engine power test as seen from the exhaust. This example is a GM 3800 engine with coil pack ignition. Engine speed is 1500 rpm; time between trigger events is 78.5 ms. This looks to be a normal pattern for coil pack ignition systems.

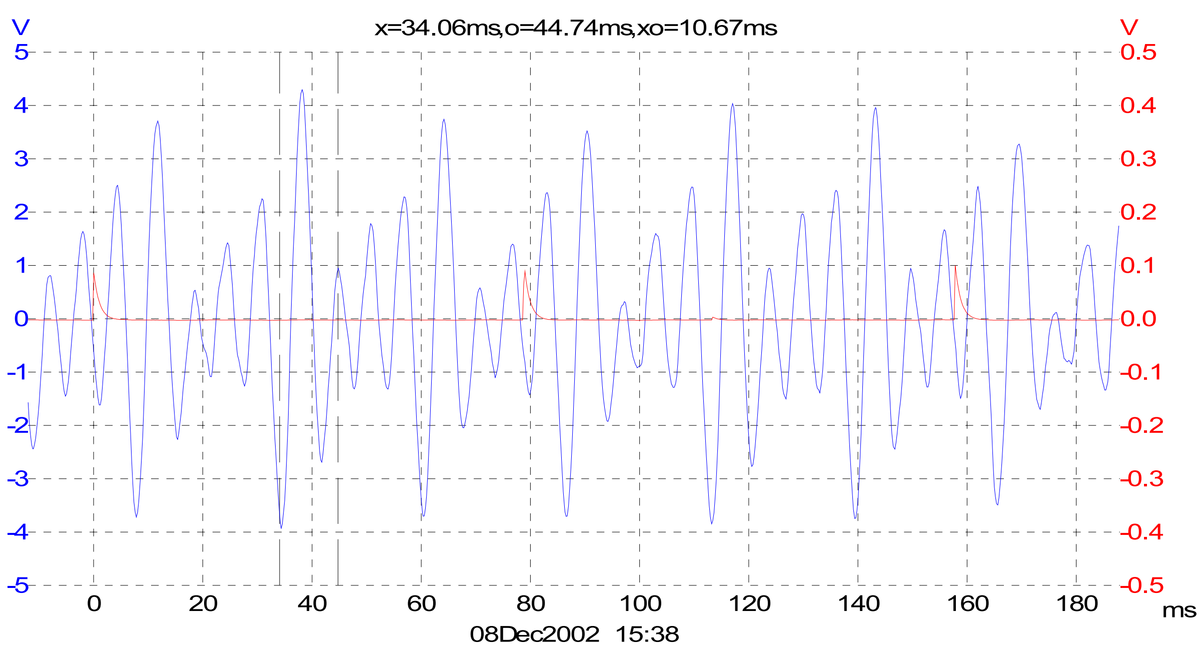


Figure 12

8. ***Basic Test Combinations***

There are 3 basic test combinations recommended at this time to speed analysis with the FirstLook sensor. First is a Base cylinder efficiency test combination. This can be done by using the Triggered Cranking Exhaust Test and the Triggered Cranking Vacuum Test. Second would be a Running cylinder contribution test combination. This should be done using the Triggered Engine Idle Test and Injector Analysis from the Regulator Test. Last would be an Intermittent Test combination. This can be done using Triggered Engine Idle Test, Injector Analysis from the Regulator and Triggered Braked Load Test (this test could be run as a Dyno test). As with any new technology we are constantly looking at new analysis paths with our sensor. To this end we have set up a web site, www.senxtech.com, where we can share information, analysis, waveforms, tips, and tricks. Also it is a place to send questions, find help, and get copies of update material. The web site and waveform library is for you to use to further your knowledge and help with the ultimate goal, repairing vehicles.

A. *Base Cylinder Efficiency*

When running this test sequence you can verify the base engine condition of the engine. These tests allow us to look at the action of the valve train and cylinders; exhaust valves through the Triggered Cranking Exhaust test and intake valves through the vacuum port using the Triggered Cranking Vacuum Test. Also if the same cylinder fails both the intake and exhaust tests you can speculate either a cracked head between valves or a problem with the piston or rings. If any problems are found with these tests, you now know which is the deficient cylinder and can continue with other diagnosis on that cylinder alone. This becomes very helpful as it is increasingly difficult to get to plugs in modern engines.

B. *Running Cylinder Contribution*

If the base engine functions are in proper working order and are not a contributing factor we can now do the run sequences. The Triggered Engine Idle Test quickly determines which cylinders are contributing to the overall performance of the engine. As you review the individual test procedures and the waveform analysis sections you can see that non contribution by a cylinder becomes very evident with a dropout followed by a compensation curve of the waveform. As with any tool the more you use the tool the easier it becomes to pick out faults. The Injector Analysis from the Regulator gives us a unique view of the injector function, in sequentially injected engines. This test allows the viewing of the individual injectors as they discharge fuel into the specific cylinders, also showing the recovery back to base fuel pressure. This becomes a fast and easy we to diagnosis injector failure, through viewing their contribution to total engine function

C. *Intermittent*

The most challenging and time consuming job in diagnosis is intermittent testing. Because the FirstLook sensor is looking at unprocessed data, it can help you pickup these failures more quickly. If we expand the time base on the lab scope we can see cylinder related failures that are not consistent enough to be tracked in other ways. In some cases it can be seen right on the Triggered Engine Idle Test as an event that occurs at idle. When a load is needed to reproduce the problem a Braked Load test can be performed to track the fault. (This can also be done on a Dyno if one is available.) Considering that many modern lab scopes have a glitch capture function, this can be used to catch the problem as it happens. Also the Injector Analysis from the Regulator can be used to track failures to a single injector circuit. (Always remember there is more in the injector circuit than just the injector. Often the driver circuit is damaged when an injector fails.) Watching an intermittent failure by this method allows us to eliminate possible causes quickly, and move more efficiently to a proper diagnosis and ultimately a repaired vehicle.

9. ***Waveform Analysis***

We have learned how the timing chart is used and how the firing order is offset from trigger reference. This offset applies no matter with what four stoke internal combustion engine you are working. In this section we will become familiar with how to use the information gathered with the lab scope and look at several waveforms and the information contained within.

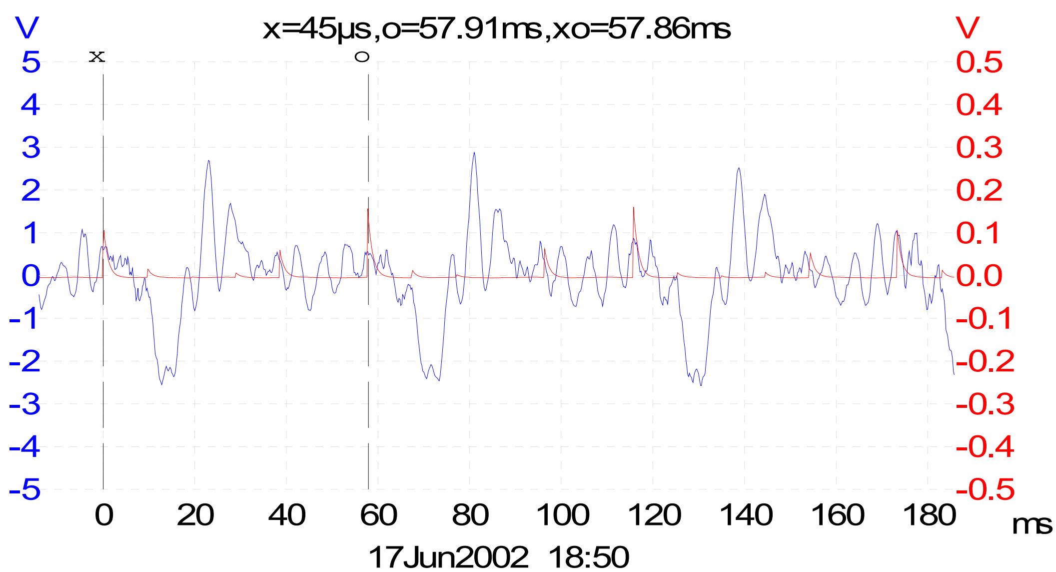
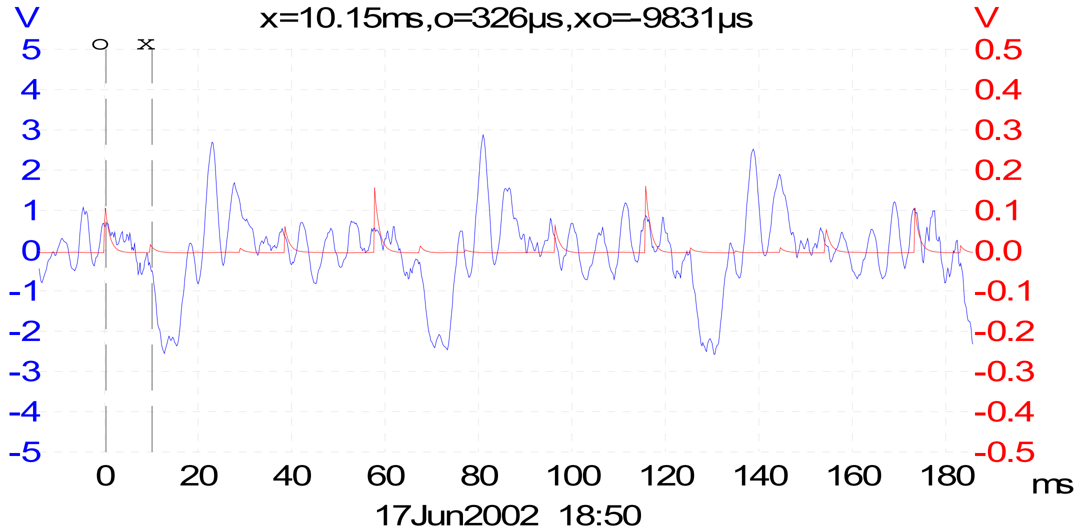


Figure 13

The waveform in Figure 13 shows a six cylinder engine with a repeating problem. Starting from the first trigger point (X) we see a 57.86ms time elapsed between trigger events. This tells us, by looking at the timing chart (Figure 12), that the pattern was taken at an engine speed of approximately 2100rpm. Looking at the timing chart for a 6 cylinder engine we can determine that each cylinder occupies approximately 9.5ms of the time between trigger reference points. In Figure 15 we divide the window and see which cylinder has the problem.



Fi

gure 14

The firing order for this engine is 1,6,5,4,3,2. With the trigger on cylinder #1, then the scope pattern as seen through the exhaust is read as 3,2,1,6,5,4 after taking into account the required cylinder offset. So the first spacing between o and x is cylinder number 3. Now we can easily see that the next cylinder in the order or cylinder number 2 is where the problem lies. The waveform in Figure 15 verifies this finding. With the cursors over this area we have now quickly determined the problem cylinder.

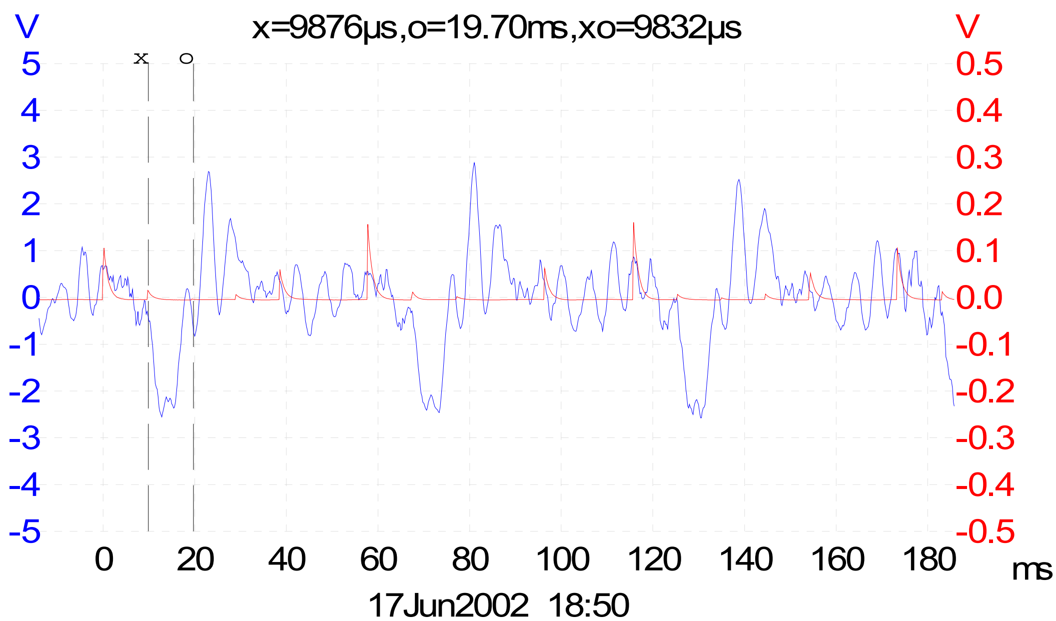


Figure 15

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Next let's interpret another diagnostic waveform in Figure16.

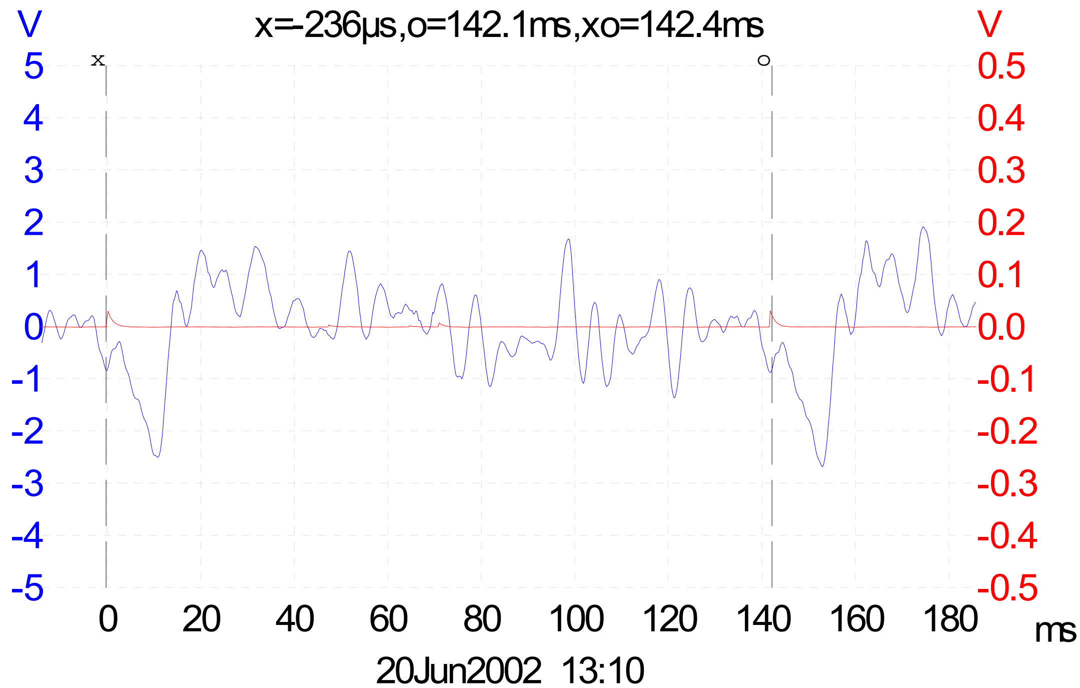

Figure 16

The pattern displayed in Figure 16 is from a GM 3800 V-6. By looking at the automotive timing chart we can determine that the engine speed is approximately 850 rpm. If we look at the chart we will find that the cylinder spacing is 23.5ms. Also knowing the cylinder offset is two cylinders we determine that the firing order on the display is 3, 2, 1, 6, 5, 4. So let's look at the first 23.5ms division on the pattern (Figure 17).

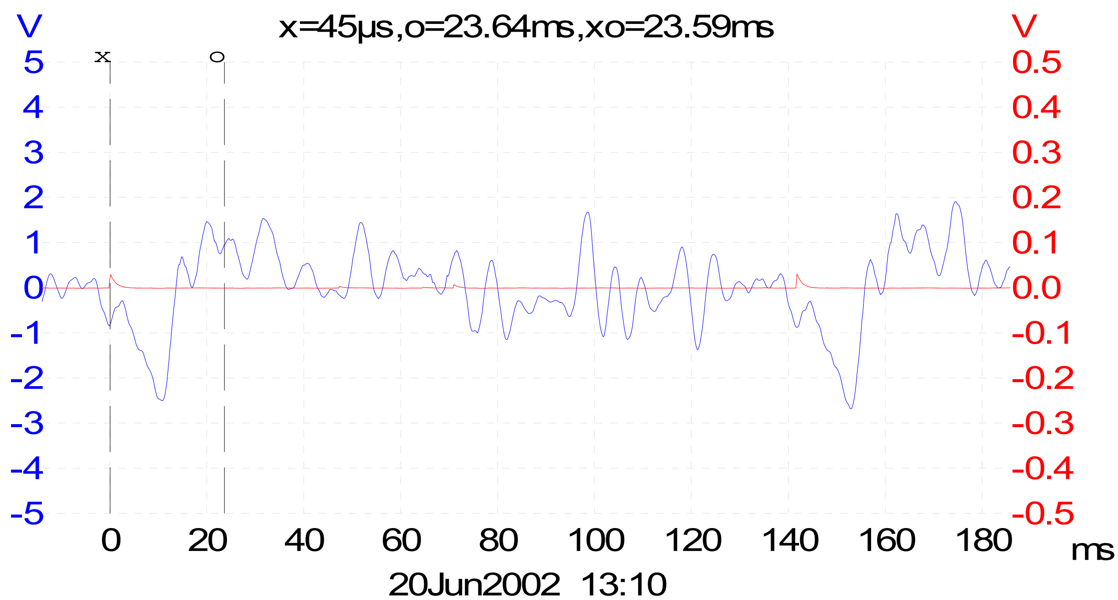

Figure 17

The drop out in this pattern is occurring on cylinder number 3. Looking farther to the right at the next trigger reference point you can see the pattern repeat itself. Also if you look just after the dropout you can see the engine compensating for the loss of power in cylinder number 3.

Lastly, let's look at a cranking waveform pattern (Figure 18).

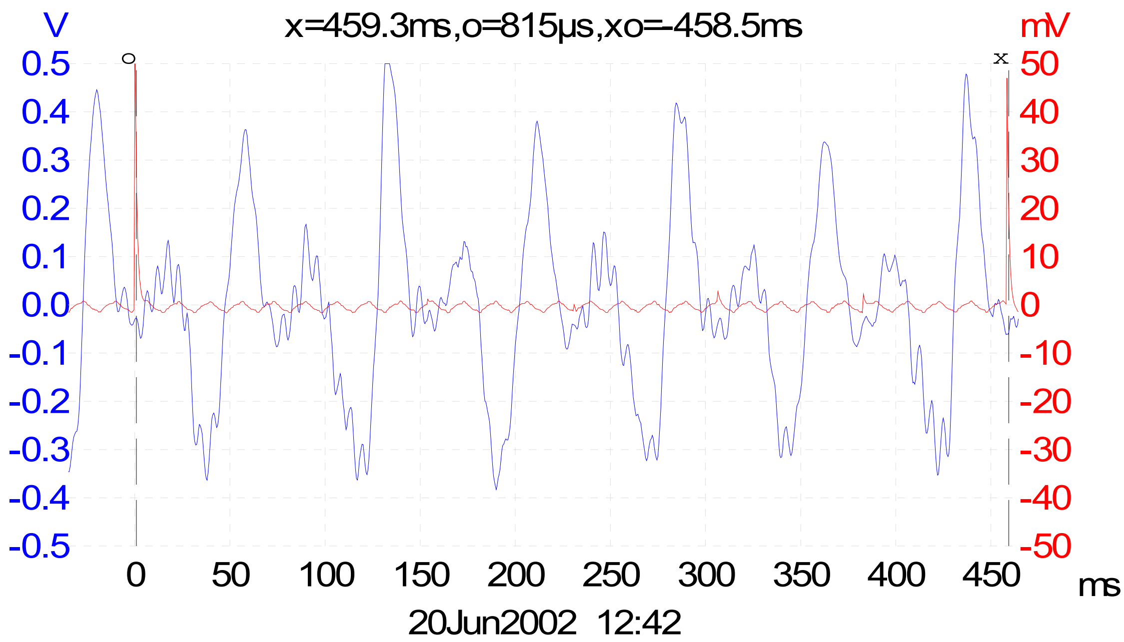

Figure 18

Figure 18 is a good example of a cranking test on an engine that is in very good condition. Notice the symmetry in the waveform, showing good performance throughout the test.
The timing we are seeing between trigger references is 458.5ms, which makes the cranking rpm of this engine approximately 260rpm as referenced by the timing chart.

These patterns should give you a good starting point for your engine diagnostics. Check with our web site www.senxtech.com for future examples. Thank you again for your investment in the **FirstLook Automotive Engine Diagnostic Sensor**.

10. Injector analysis from the regulator

In field testing of FirstLook, it was brought to our attention by Tom Roberts of Autonerdz, that the sensor could be used on the fuel pressure regulator for a unique look at injector function.

To perform this test:

1. Disconnect vacuum hose from pressure regulator
2. Plug vacuum hose
3. Place reducer hose on sensor
4. Place reduced hose directly to regulator port
5. Trigger using Injector #1 (use either voltage waveform or current ramping)
6. Set voltage scale for Channel 1 on Lab scope to 1 volt AC
7. Set voltage scale for Channel 2 on lab scope to 50 volt DC (Voltage Waveform)
8. Set voltage scale for Channel 2 on lab scope to appropriate voltage range depending on current probe equipment you are using. (Current Ramping)
9. Triggering can also be achieved using cylinder # 1 as we did in the following examples
10. Start engine and let idle stabilize
11. Readings can be taken at desired RPM.
12. Save pattern.

Let's take a look at a waveform produced by this method. Figure 19 was taken using a cylinder # 1 trigger on channel 2 and the sensor signal on channel 1. Let us consider what happens when an injector is opened, as it affects the regulator. The sudden drop in fuel pressure causes a fluctuation in the regulator. The fuel pump than compensates to fill the void left by the exiting fuel, thus returning the regulator to it starting position. In figure 19 we can view the resulting waveform caused by this action. Notice the sharp change followed by the compensation curve back to the base state, the center line (0 line) can be considered the base state. When using the cylinder firing to trigger the regulator waveform, the companion cylinder in the firing is actually on intake stroke just before the number one firing. If we look at figure 20 we can see the 0 cursor line on the number 1 cylinder firing the x cursor line is at the point where cylinder #4 injector is opened. (This assumes a firing order of 1342) The sharp drop off after the x cursor is the injector discharge followed by the compensation curve back to the base line followed by the next discharge in the order.

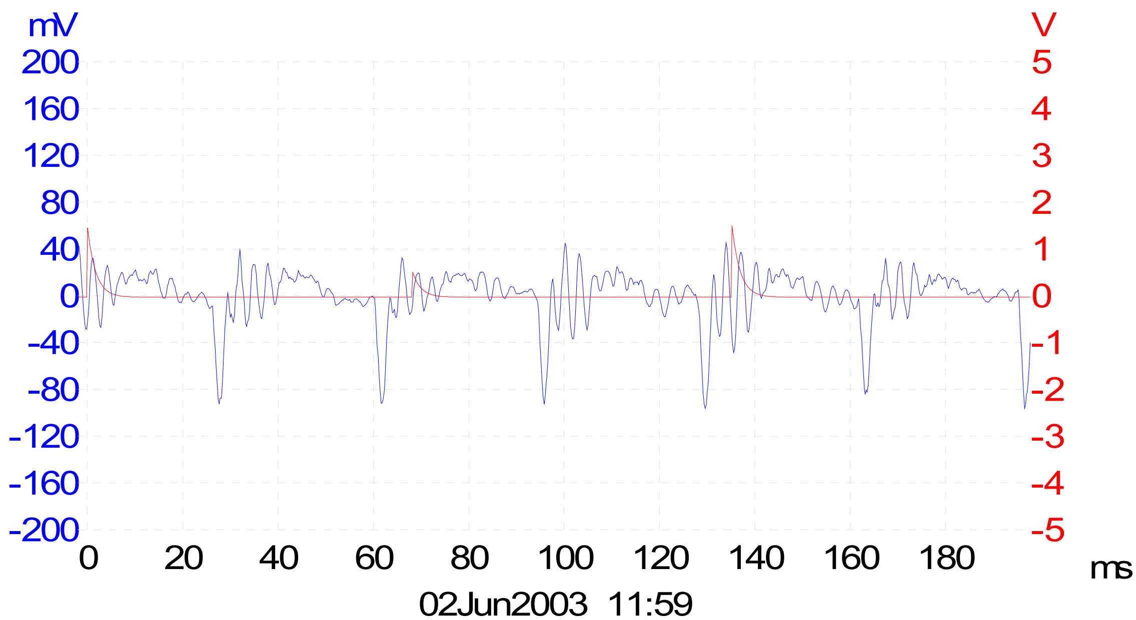

Figure 19

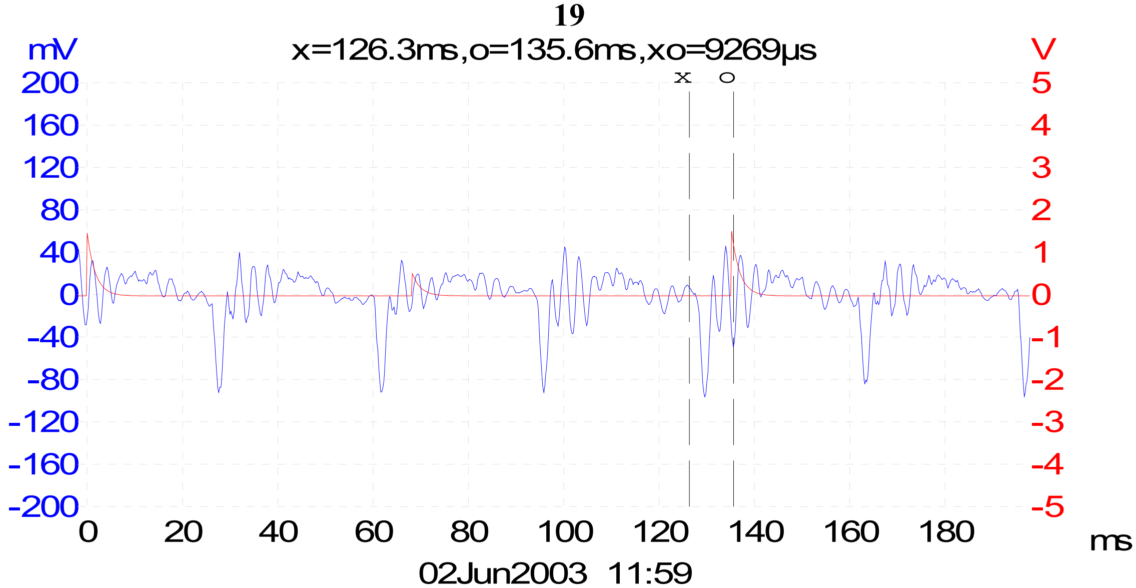

Figure 20

11. Support and Warranty

Support

For support questions or warranty assistance contact:

North American Distributor - Interworld Electronics Inc.
145 Tyee Drive, Suite 1280
Point Roberts, WA. 98281
Phone 877-902-2979 Fax 877-329-4324
Or visit our web site at http://www.interwld.com

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SenX Technology, LLC warranties the products described herein for a period of 1 year under normal use and service from the date of purchase, that the product will be free of defects in material and workmanship. This warranty does not cover ordinary wear and tear, abuse, misuse, overloading, altered products, or damage caused by the purchaser connecting the unit incorrectly.

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