February 2010

Technicians Service Training

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David Hobbs

Editor

Jerry "G" Truglia

Engine Knock Sensors II

We continue our investigation of engine knock sensors with a look at one and two-wire sensors.

In the previous issue we discussed the various causes of engine knock. Prior to the age of electronic engine control, an engine designer had a limited number of effective tools to guard against engine knock. Principle among these were combustion chamber design, the octane of the fuel used and mapping of the spark advance curve. The designer couldn't risk the possibility of engine damage caused by knock, so it was always necessary to keep the engine well short of the point where it might begin. This assured engine longevity, but hurt performance.

Modern engines are now fully controlled by electronics. Engineers no longer have to settle for a conservative preset spark advance curve. Spark advance can now be controlled dynamically. This dynamic control allows the engine control module (ECM) to take into account changing engine operating conditions as well as the available octane of the fuel, then use that information to extract the maximum amount of engine performance without running the risk of damaging spark knock.

(Con't on page 3)

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Currently there are TST chapters in Connecticut, Massachusetts, New Jersey, New York and membership continues to grow. For more information you can call TST headquarters at:

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What is TST?

TST is a group of dedicated technicians and instructors committed to the continuing education of our fellow technicians. We provide once a month training seminars to technicians at a reasonable price. TST brings our members nationally known instructors and state of the art training.

Our Goal & Mission Statement

- ***Keep our fellow technicians up to date with the latest technology.***
- ***Provide training seminars for a reasonable price.***
- ***Deliver information that the technician can use now.***
- ***Keep technicians informed of information affecting our industry.***
- ***Increase consumer awareness of what a good technician is.***

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TST membership includes special pricing on once a month weekday night seminars and the occasional full Saturday seminar. With a **$75.00 yearly membership, the monthly seminars are only $65.00. TST classes are NOT sales or product seminars.** The instructors that TST brings in are all "hands-on" industry experts with up to date, cutting edge knowledge that you can use in your shop the next day. That's 65 dollars for a seminar in which you are able to learn something useful, for fixing those tough jobs that we all see on a regular basis. Our instructors are masters at making the complex understandable. Membership also includes a Monthly Newsletter full of real world technical articles, diagnostic case studies, and solutions to the kinds of problems you see in your bays each week.

The following are some of TST's regular instructors:

Bernie Thompson of ATS www.ATSnm.com
John Thornton formerly of Team AVI
Wayne Colonna of ATSG www.ATSGmiami.com
Jorge Menchu the "Labscope Guru," owner of AES
www.aeswave.com/aboutaes.htm
John Anello Auto Tech On Wheels www.autotechonwheels.com
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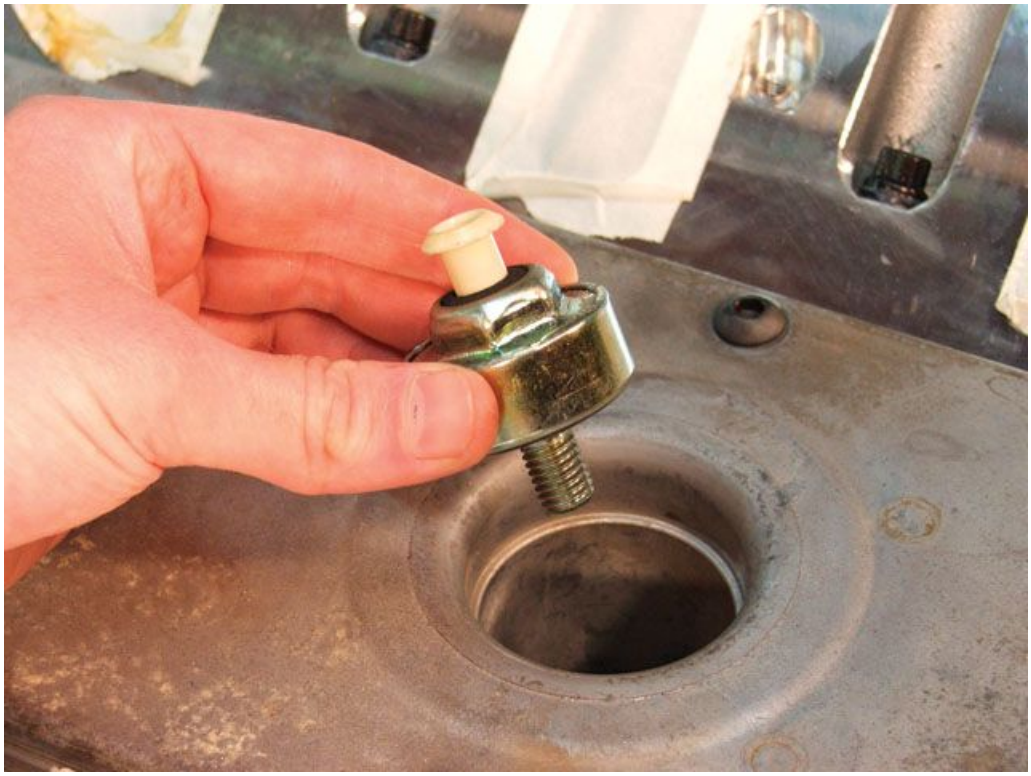
Engine Knock Sensors II *(con't from p. 1)*



The key sensor used to maintain dynamic control of spark advance and extract maximum performance is the engine knock sensor. For any given operating situation, the ECM attempts to deliver the maximum available performance by advancing the ignition. If this advance were unchecked, it would inevitably lead to engine knock.

The control unit needs a sentinel to report knock as soon as it begins. Ignition timing is then retarded by the ECM, and the knock stops. The ECM repeats the process by steadily advancing the timing until knock is detected, then retarding the timing until the knock stops. This closed loop process allows the engine to deliver maximum performance under all conditions, without the risk of damage or lost performance caused by knock.

Two major knock sensor designs are used today: broadband single-wire and flat response two-wire knock sensors. Both sensor designs use piezoelectric crystals to produce and send voltage signals to the ECM. The amplitude and frequency of this signal varies, depending upon the vibration levels within the engine.

Broadband and flat response knock sensor signals are processed differently by the PCM. Broadband sensors use a single-wire circuit. This sensor type can respond to knock frequencies up to 1000 Hz from the design frequency value. This allows the sensor to accommodate shifts in engine knock frequency with changing engine operating conditions. The sensor's high voltage output allows the use of a single, non-shielded output wire and a low impedance measuring circuit, while providing reduced susceptibility to electromagnetic interference (EMI). *(Con't on page 4)*

Engine Knock Sensors II *(con't from p. 3)*

Some PCMs output a bias voltage on the knock sensor signal wire. The bias voltage creates a voltage drop that the PCM monitors and uses to diagnose knock sensor faults. The knock sensor noise signal rides along this bias voltage. Due to the constantly fluctuating frequency and amplitude of the signal, it will always be outside the bias voltage parameters. The PCM in many applications will learn the knock sensor's normal noise output.

The PCM uses the noise channel and the knock sensor signal that rides along the noise channel similar to bias voltage systems. Both systems constantly monitor the sensor output, watching for a missing signal or one that falls within the noise frequency channel.

Flat response knock sensors use a two-wire circuit. This is a self-generating piezoelectric design that requires no power to the sensor. The sensor has a flat frequency response over the range of 5 to 18 kHz. This allows the sensor to be used on different engines by adjusting the filter frequency of the signal processing electronics to match the knock frequency of the engine.

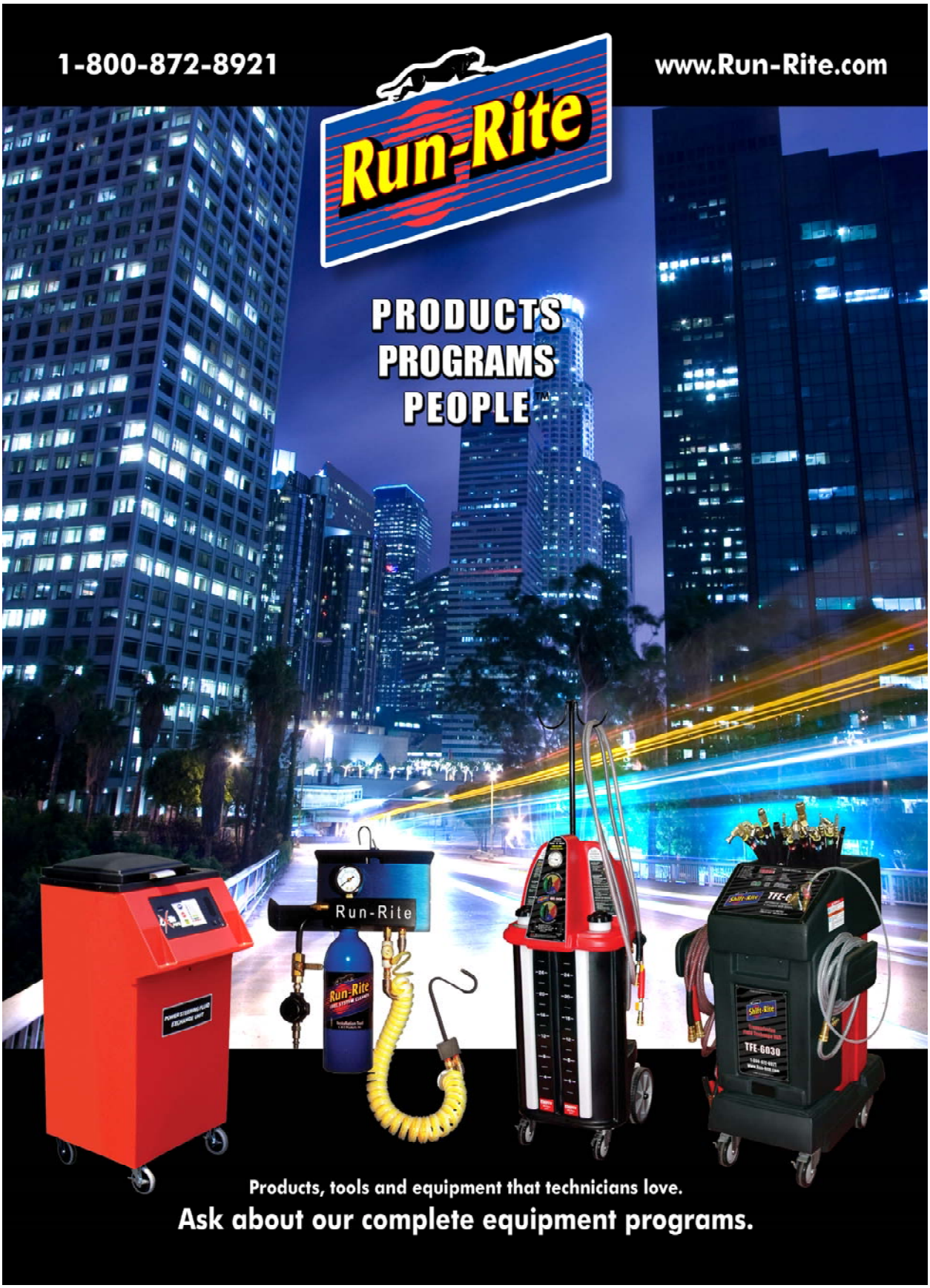
The sensor responds to knock frequencies that are higher than the primary knock frequency, allowing the higher knock frequencies to be used by a control system, either individually or combined with the primary knock frequency.

The signal rides within a noise channel which is learned by the PCM. The noise channel is based upon the normal noise input from the knock sensor and is known as background noise. As engine speed and load change, the noise channel upper and lower parameters will change to accommodate the knock sensor signal, keeping the signal within the channel. When there is knock, the signal will move outside the noise channel frequency and the PCM will reduce spark advance until the signal moves back inside the noise channel frequency.

(Con't on page 7)

It's very difficult to make an engine knock when you want it to. Here, an air chisel and a blunt bit are used to temporarily mislead the knock sensor.

Picture Courtesy of Bernie Thompson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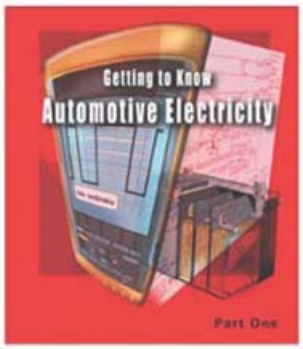

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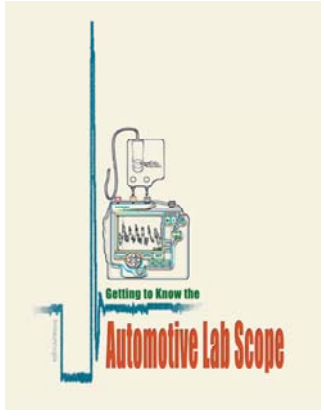
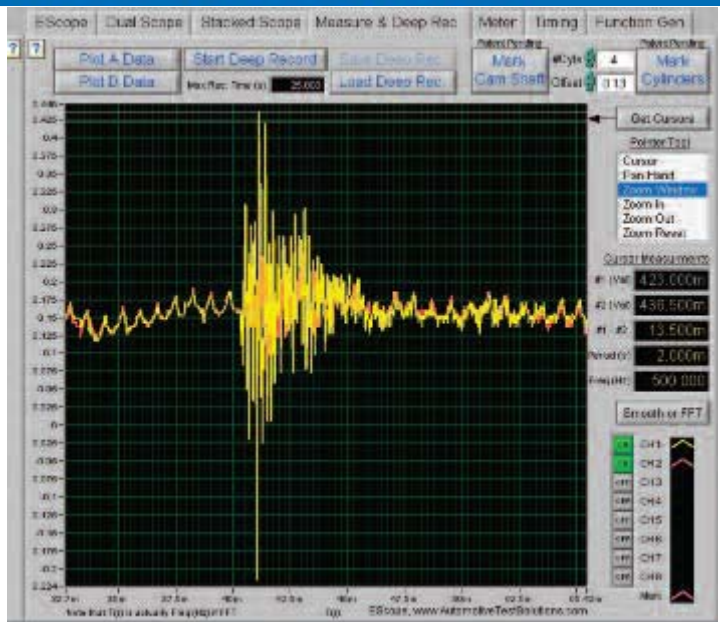


Engine Knock Sensors II *(con't from p. 4)*

Using your oscillosope to check patterns produced by good components will help you identify defective components. The air chisel produced this signal from the front knock sensor on a 1996 Volvo 850.

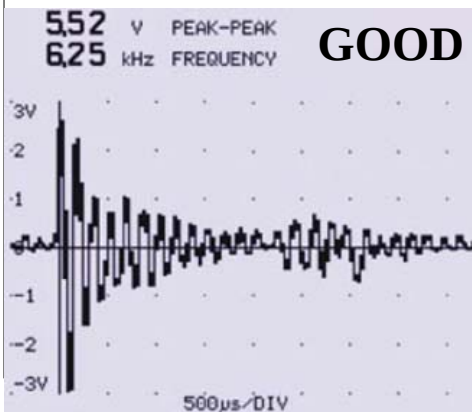


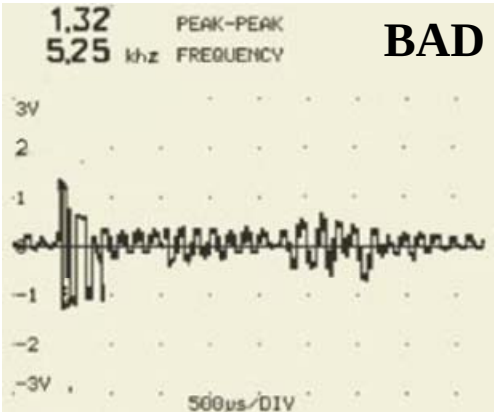
Both the number and position of the knock sensors must be carefully selected so that knock from any cylinder or cylinders can be recognized under all conditions, with special emphasis on high loads and engine speeds.

The knock sensor mounting position is generally on the side of the engine block or under the intake manifold. Four cylinder engines are normally equipped with one sensor, five and six cylinder engines with two and eight, ten and twelve cylinder engines with two or more knock sensors.

When you connect to the knock sensor with your labscope, you want to see a strong signal. Weak signals indicate the sensor is improperly mounted, its wiring harness has issues, or needs to be replaced.

(Con't on p. 9)





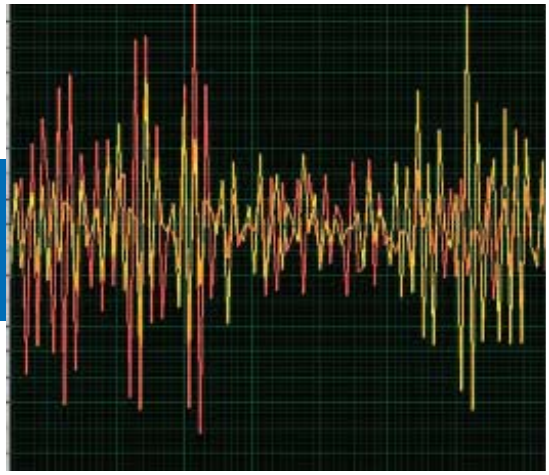
Engine Knock Sensors II *(con't from page 7)*

The sensor signals are evaluated by the PCM. A reference level is formed for each cylinder, which is continuously and automatically adapted to operating conditions. A comparison with the useful signal obtained from the sensor signal for every combustion process in every cylinder allows the PCM to determine whether knocking is occurring. If so, the ignition point is retarded by a fixed amount, 3° of crankshaft rotation for example, for the cylinder involved.

This process is repeated for every cylinder for every combustion process that has been recognized as knocking. Once the knock subsides, the ignition point is advanced in small steps until it has returned to its spark advance map value.

A defective knock sensor on a 2000 Toyota Avalon engine produced the waveform below during a snap throttle test.

Since the knock limit varies from cylinder to cylinder within an engine and changes dramatically within the operating range, the result is an individual ignition point for every cylinder. Cylinder-selective knock recognition and control makes possible the best optimization of engine efficiency and fuel consumption. If the vehicle is designed for operation with unleaded premium fuel, it can also be operated with regular unleaded fuel with slightly reduced performance and without the risk of internal engine damage.



You can see quite a bit more scope activity during a snap throttle test after the knock sensor had been replaced on the same vehicle.

(Continued on page 11)


9 of the Top 10* "Check Engine" DTCs can be diagnosed with a Smoke Wizard.
Maybe it should be called the "Smoke Wizard" Light
Use with shop air or any inert gas (like nitrogen) for safety
Pressure and vacuum decay tests
Automatic flow shut-off avoids filling bay with dangerous fumes
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1. Do you want seminars to continue in your area?

2. Do you find the seminars useful?

Please ask a fellow technician to come and check-out our seminars so we can continue to bring you the best available information each month.

We need your support:

Thank you,
G Truglia

Engine Knock Sensors II *(con't from page 9)*

In dynamic operation, knock frequency will increase under such conditions. To reduce knock, an individual spark advance map can be stored in the electronic control unit for the two fuel types.

After start-up, the engine operates with the "premium" map. The PCM is switched to the "regular" map if the knock frequency exceeds a predetermined limit. The driver is not aware of this switchover; only power and fuel consumption will be slightly reduced.

Article Courtesy of Wells Manufacturing Corp.

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March 31st is the deadline to sign up for your ASE Exams. The actual exams are on the 6th, 11th, and 13th of May. Everything you learn today should equip you to take the A6 Electrical exam and to confront electrical problems in your shop.

- The Big Event is next month! ***Bernie Thompson***, ***Scott Manna***, *and* ***John Thornton*** *are presenting in other states but only at TST does it cost as little as $175.* What are you waiting for? Prices go up after today!

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