The "Shop Scope"

The shop scope provides an easy way to perform an ignition system quick check that can also identify engine mechanical problems and air/fuel mixture imbalances.

The automotive oscilloscope serves as a valuable tool in the diagnosis of the ignition system, fuel system, charging system, and engine mechanical condition. Commonly referred to as a "scope", the oscilloscope provides the technician a method to observe the ignition events for each of the engine's cylinders, by displaying individual ignition system voltages across an active display.

The oscilloscope pattern is a voltage line plotted over a specific length of time, representing the ignition system's primary or secondary circuit voltage. This pattern is continuously updated to reflect ignition system voltage changes throughout various engine operating conditions. By examining the oscilloscope pattern, the technician can see the ignition system voltage fluctuate from the time the spark plug fires, through the duration of the spark, as the spark is extinguished, and as the ignition coil recharges to fire another cylinder. Many engine problems, ignition related or otherwise, will show up on the oscilloscope pattern as abnormal.
A traditional volt meter displays the instantaneous voltage for the circuit being measured. Unlike the volt meter, the oscilloscope has the ability to display the voltage changes that take place through a specific time by "drawing" a line on the screen. The higher the voltage being measured, the higher the line extends vertically. As time passes, the line moves horizontally across the screen to the right. This line, fluctuating up and down across the screen, forms a pattern that is repeated once per ignition cycle. The vertical scale measures voltage in variable ranges, and the horizontal line measures time in selectable increments.

Many types and brands of automotive oscilloscopes are available. Modern machines are PC based with built in software files to aid the operator in machine programming, as well as vehicle diagnosis. They may also have updated connectors and interfaces to accommodate modern ignition systems. Older machines are more common and are often adjusted with a set of knobs and switches on the face of the machine. It is advised that you consult the Operator’s Manual provided by the manufacturer for specific information on hook-up, adjustment procedures, and safety precautions.
Secondary Ignition Patterns

The Secondary Scope Pattern is the most useful pattern for diagnosing possible ignition system, engine mechanical, engine electrical system, and emission control system problems. It consists of the **Firing Section, the Intermediate Section, and the Dwell Section**. Each section represents a different period of time during the entire ignition sequence for a particular cylinder.

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**Secondary Pattern**

The **Firing Section** represents the voltage fluctuation of the secondary ignition system from the time the spark is initiated until it is completely extinguished. The **Firing Line** represents the voltage required to overcome the rotor and spark plug gap resistance. Firing voltage is normally between 5 and 15 kilovolts (KV). Typically, Firing Lines should not vary by more than 3 KV between cylinders. Also, the height of the Firing Line increases with secondary resistance. The Firing Line begins when the igniter cuts the primary current flow through the ignition coil and the collapsing magnetic field in the coil induces voltage to the secondary ignition system.

Once spark has been initiated, considerably less voltage is required to maintain the spark. The vertical line immediately following the firing line represents the voltage required to maintain the spark and is known as the **Spark Line**. It should remain fairly level and should measure from 0.8 to 2.2 milliseconds (ms) time on a properly operating engine. The Spark Line is a good indicator of air fuel/ratio and secondary resistance. The point at which the spark line begins to drop sharply is the point at which spark is extinguished.
The Intermediate Section begins where the Firing Section ends. The voltage oscillations seen on the oscilloscope screen represent the remaining ignition coil energy being dissipated after the spark is extinguished. The Intermediate Section ends when the igniter transistor turns on, applying power to the primary ignition circuit.

The Dwell Section begins when the igniter applies power to the coil, allowing it to "recharge" to fire the next cylinder. The short down spike followed by diminishing oscillations at the beginning of the Dwell Section represent the build up of the magnetic field in the coil. Normally you should see several oscillations; however, on some electronic ignition systems a single down spike with no oscillations may be normal. The Dwell Section ends when the igniter stops primary current flow causing a spark in the next cylinder.
Scope Patterns The oscilloscope screen can display secondary ignition patterns for all cylinders simultaneously in the Display, Raster, or Superimposed mode.

**Display Pattern**

The Display Pattern shows all of the cylinder patterns one after another, in the sequence of the firing order. On most oscilloscope screens, the Firing Line of the number one cylinder appears at the extreme right. The Display Pattern is primarily used to compare Firing Line height.

**Raster Pattern**

When the Raster Pattern is chosen the individual cylinder patterns are shown vertically, one above the other. The pattern begins at the bottom of the screen with the first cylinder in firing order and follows the firing order to the top of the screen. The advantage of using the Raster Pattern is it extends the individual cylinder patterns across the entire screen. This gives the technician the ability to examine individual sections of the pattern and to compare any variances. The firing lines for the individual cylinders are displayed at the extreme right.
Superimposed Pattern  When the Superimposed Pattern is chosen, the individual cylinder patterns are placed one on top of the other. This pattern is especially useful when checking the overall uniformity of the ignition system. As with the Raster Pattern, the Superimposed Pattern places the Firing Lines on the extreme right of the screen.

Sample Scope Patterns  An essential part of diagnosis with an automotive oscilloscope is a basic understanding of how various system malfunctions appear on the oscilloscope screen. Patterns will vary slightly from textbook illustrations and between engine make and type. For this reason, it is also important to examine oscilloscope patterns for uniformity between cylinders. Look for patterns that are not uniform or that vary greatly from the norm. The following examples show common engine conditions detected by the automotive oscilloscope. They do not represent all possible problems; however, they do serve to familiarize the technician with the oscilloscope’s basic diagnostic capabilities.
When one or more of the displayed Firing Lines exceeds the others by more than 3KV, a problem exists in the affected cylinder(s) which causes the voltage required to bridge the spark plug and rotor gap to rise. When this happens, the output voltage of the coil continues to rise until it is high enough to fire the spark plug. The raised voltage appears as a higher Firing Line. The voltage of the spark line will also be higher and not as wide.

Possible causes include:
- Worn spark plug
- Breaks in spark plug wire
- Corroded terminal in the distributor cap
- Vacuum leak near the affected cylinder
- Plugged fuel injector in the affected cylinder

A pattern in which all Firing Lines are uniform, but high is caused by a condition that requires excessive voltage to fire the spark plugs.

Possible Causes Include:
- Open high tension coil wire (except on DIS ignition systems)
- Worn spark plugs
- Rotor gap too wide
- Retarded spark timing
- Fuel mixture too lean
- Faulty distributor cap
This pattern is caused by low secondary resistance for the affected cylinder. Also, the current for the low cylinder may have found an alternate path to ground that has lower resistance.

Possible Causes Include:
- Low compression
- Fouled spark plug
- Shorted spark plug wire
- Spark plug with too small a gap
- Cracked spark plug insulator
- Leaking injector at affected cylinder

One or More Spark Lines Sloping Down

This pattern is caused by high resistance in the secondary circuit of the affected cylinders.

Possible Causes Include:
- High resistance in the spark plug wire
- Distributor cap terminals burned
- Spark plug with too large a gap
- A leaky injector at the affected cylinder
The technician can momentarily snap the throttle and watch the rise of the individual spark lines. Spark Lines should rise uniformly and only slightly (about 3 KV). Spark Lines that show excessive voltage rise may be the result of excessive secondary resistance or fuel mixture imbalances for the affected cylinders. Spark Lines that show no voltage rise may be the result of poor secondary circuit insulation or engine mechanical problems.

Possible Causes of Excessive Voltage Rise Include:
- Spark plug gap too wide
- Open spark plug wire
- Improper fuel mixture
- Open spark plug resistor
- Vacuum leak near the affected cylinder

Possible Causes of No Voltage Rise Include:
- Shorted spark plug wire
- Poor high tension wire insulation
- Fouled spark plug
- Low compression in the affected cylinder