Probing Auto Electronics

Help your neighbour identify his car's problem and be an electronics hero!

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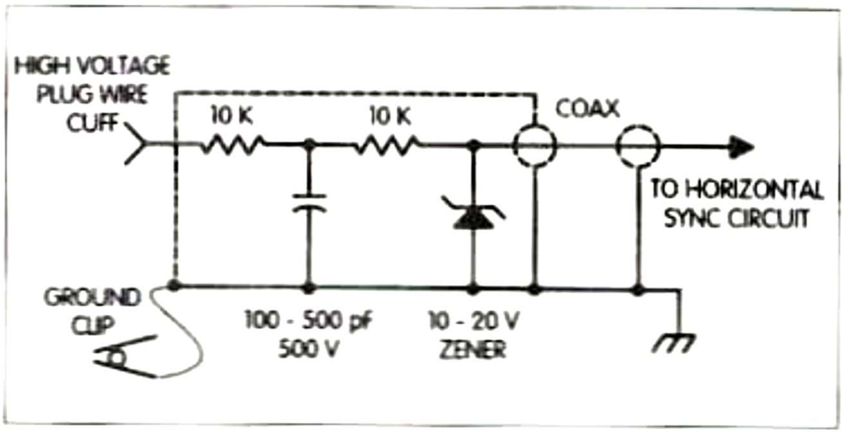


Fig. 1. Sync input circuit.

To make up an engine analyser using an oscilloscope, it will be necessary to make up a couple of interface boards to be used as scope probes as shown in **Figs. 1 and 2.**
Sync for the horizontal of the scope is obtained from the high voltage using the circuit shown in **Fig. 1.**
A wire cuff or broad faced spring clip is used to provide a capacitive coupling to the HV wire, as a direct connection is not desirable. The circuit integrates the HV pulse to create a single constant amplitude trigger pulse suitable for synching the scope (a Zener diode is used as an amplitude limiter).

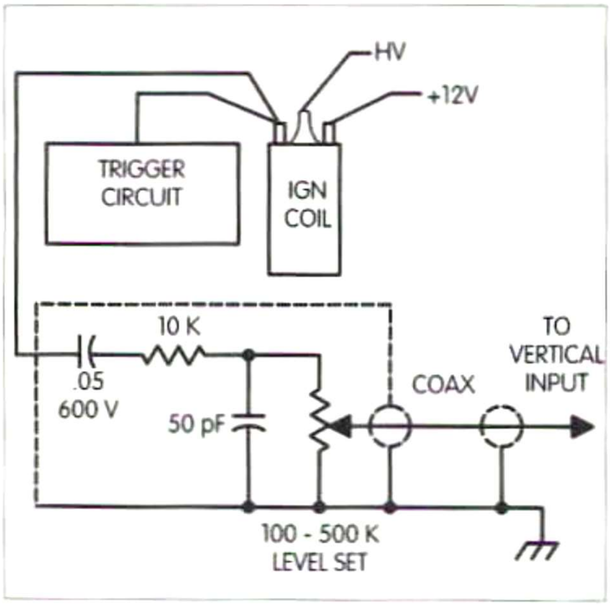


Fig.2.Pulse input circuit to vertical amplifier

The HV pulse train to be analysed is obtained from the primary side of the ignition coil using the circuit shown in **Fig. 2** and is applied to the vertical input of the scope. All HV sensing is done in the primary of the coil, not in the actual HV circuit. All of the system's performance is viewable in the primary side of the coil. A small amount of integration is performed by the interface board, but only enough to make the pulse visible on the screen.
The amplitude pot is used to bring the vertical signal amplitude within the control range of the scope's input attenuator. The pot remains fixed after the initial adjustment. In modern engines there is a separate ignition coil for each pair of cylinders. Therefore, it will be necessary to move the vertical scope probe from one coil to another to view the next pair of cylinders.

Test preparation includes connecting the interface circuits to and starting the engine, and running the engine at idle. In operation, the scope sweep is adjusted to approximately ***20 ms /cm*** when displaying all of the plugs at once. Attaching the HV pickup (sync) to plug # 1 will allow all of the plugs to be viewed in the order in which they fire (Only when one coil is used for all of the cylinders).
Adjust the sweep timing to display four, six, or eight pulse sequences as determined by the number or cylinders present (Only two cylinders at a time can be viewed when one ignition coil is provided for a pair of cylinders).
To view a single plug, attach the HV pickup to the plug to be viewed and adjust the sweep to approximately ***1 ms/cm*** or until one pulse sequence is observed. Move the HV pickup from one plug wire to another to make pulse comparisons.

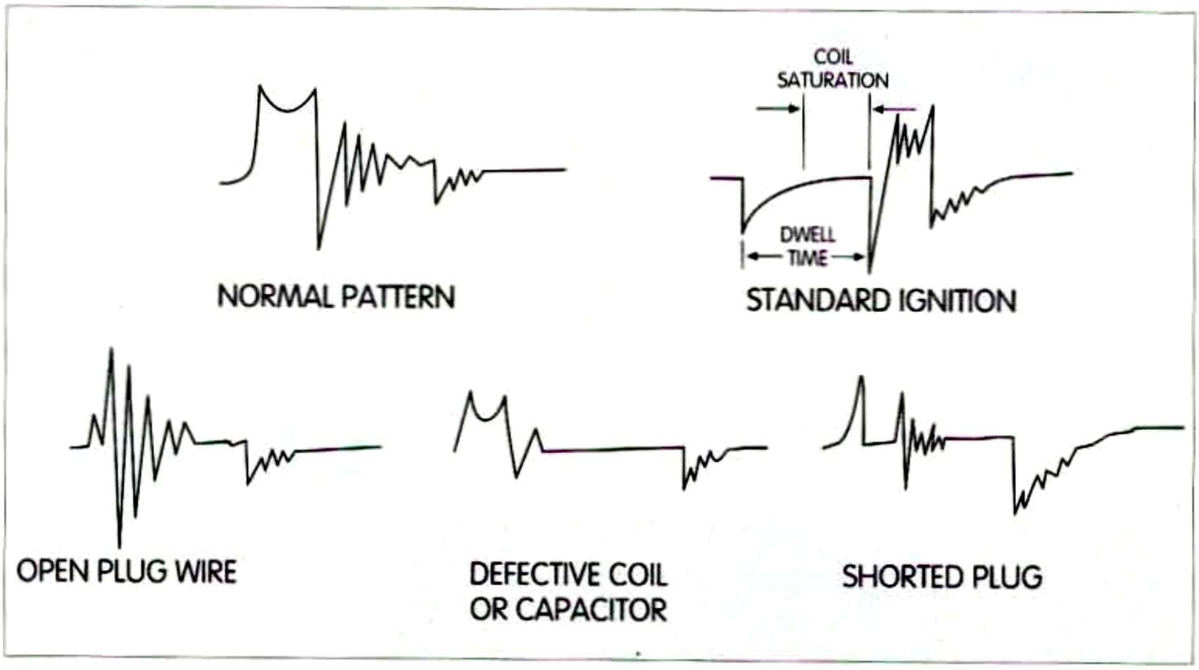
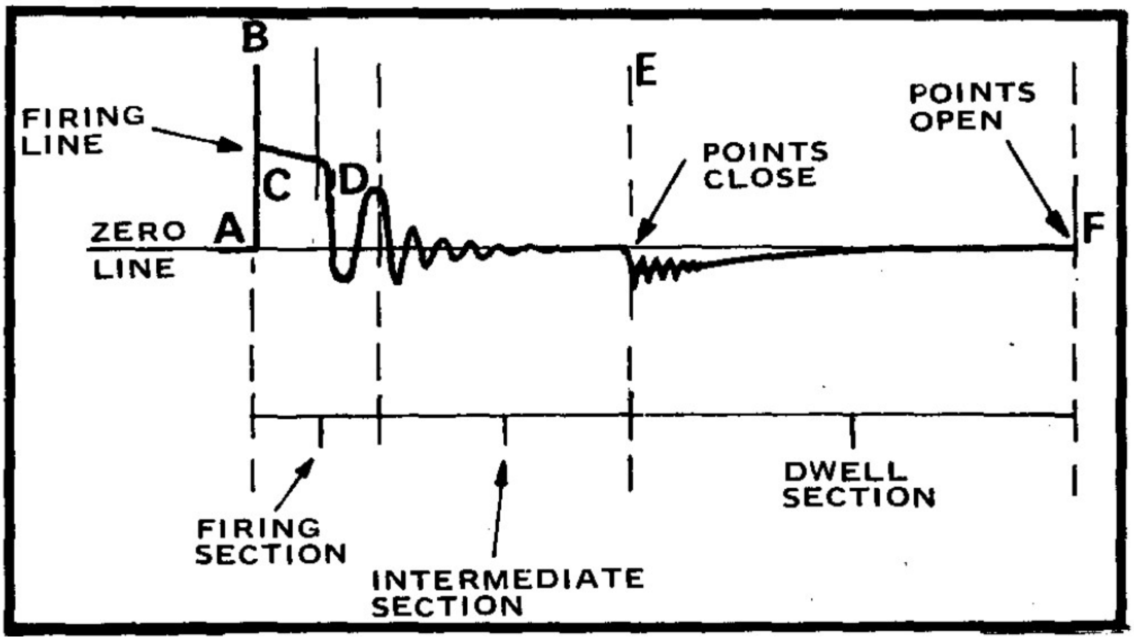


Fig. 3. Typical ignition wave patterns exhibiting specific conditions, Dwell time pattern is specific to a standard ignition system.

Typical waveforms suitable for comparison are shown in **Fig. 3.** Because the waveforms obtained vary somewhat from one engine to another, it is necessary to identify a "norm" view form for the engine being analysed.

A norm can be determined by looking first at all plugs firing (typical sweep of ***20 ms/cm***) and observing the similarity as a norm. Then note any differences in the plug patterns observed for a potential problem. Obtain a closer analysis of individual plugs by using a sweep of about ***1 ms/cm*** to provide clues as to the health of the system. To aid in the analysis, look for the series of HV pulses that occurs during a plug firing, then look for the short delay before the next firing. The right-hand end of the delay indicates the beginning of the firing cycle and the left-hand end of the next delay indicates the completion of the firing cycle. The pulse waveform between the delay periods provides the clues for comparison to the examples shown. A shorted plug wire can he simulated by holding a screwdriver between the engine block and the top of a spark plug while observing the waveform .It is not recommended, to simulate an open HV wire by removing a plug wire on electronic ignition systems, they are subject to damage when an open HV wire occurs.

Testing your Ignition with an Oscilloscope.



THE SECONDARY WAVEFORM

The simple waveform shown is a typical secondary waveform that is derived from the secondary (or high voltage) side of the ignition system. This waveform is the one most used since phenomena occurring in the primary side of the system will be reflected through the coil windings and appear in the secondary pattern.

Point A: is the instant at which the contact points open thus causing the magnetic field to collapse through the coil's primary winding. A very high voltage is thus generated in the secondary winding and this continues to rise until a spark jumps across the distributor rotor gap and the spark plug gap (**point B**). The voltage at which this occurs is known as the 'ionization' or the 'firing' voltage and may be anywhere between 5 kV and 15 kV depending on the factors outlined above.

Points C—D: after a very short time the voltage drops substantially but the arc is maintained (point **C**).The subsequent section from point **C** to point **D** is known as the spark line and when viewed on a 'scope the amount by which this line slopes away from the horizontal is directly related to resistance in the plug and coil HT leads (ignition suppression). A slope of 300 or so is OK, if it's more than that then check lead resistance with an ohm meter. The total resistance between the centre terminal of the coil and the centre electrode of the plug should not exceed about 20k assuming the rotor gap is shorted out of course! Actual resistance is not critical but anything more than 30k may cause problems. Resistance over 50k almost certainly will.

Point D: the section immediately following the end of the spark line (point **D**) should be a series of diminishing oscillations. These should appear as our illustration. If there are no oscillations, or just one or two then it's possible a shorted turn in the coil. It may not have broken down completely yet but shortly will. (See also below).

Point E: is where the contact breaker points close. It is essential that there is a gap between the last oscillation of the preceding section and point **E**, for otherwise the diminishing coil energy will be fed into the now closed points thus preventing the coil re-building its magnetic field for the next cycle of ignition. A great deal may be learnt by studying point **E** carefully, point misalignment, point bounce, burnt points etc. may be spotted at this part of the waveform. The correct waveform at point **E** should be a short downward line followed by six or so diminishing oscillations.

Point F: magnetic energy will now build up in the coil until Point **F**. This is in effect the same point as our previous point **A** but in the next firing sequence. The section from points **E** to **F** is known as the dwell section and should occupy roughly the proportion of the total, waveform as shown in our main drawing. Dwell is adjusted by varying the contact breaker gap and should be set using a dwell meter.

SPECIFIC INDICATIONS

Firing waveforms should be observed with the engine warm and running at about 1000 rpm, that is about 400 rpm higher than normal tick over speed. Check each section of each firing sequence slowly and carefully.

FIRING LINE

All firing lines should be of roughly equal height. If any plug is 10-15% or more high than the rest, connect a jumper lead to earth and short out at the plug terminal. If the firing line now decreases the fault lies within that cylinder, either a faulty plug or unusually weak mixture (probably caused by a leaking inlet manifold gasket). If the firing line does not decrease there is a partial open circuit in the associated plug lead or that lead is not making firm contact with the connector within the distributor cap. If the firing lines are unequal on a multi-carburetted engine check to see if the lines which are higher correspond to those cylinders fed by one common carburettor. If so it is probable that the mixture from the carburettors is unbalanced. A further but less common fault that may be spotted this way is an eccentric distributor cap, the gap between rotor and distributor contacts being wider on one side than the other.

At some time during the check 'snap' the throttle wide open momentarily, meanwhile watching the firing lines. They should all rise by about the same amount. If one or more lines rise substantially higher than the others then there is an open circuit plug lead or resistor, a wide plug gap or badly deteriorated plug electrode. One or more lines staying lower than normal indicates spark plug breakdown or insulation breakdown in the circuit' concerned.

COIL OUTPUT AND INSULATION TEST

While the engine is running disconnect a plug lead and observe the firing pattern for that cylinder. The firing line should rise to about two to three times its previous level (to about 20 kV) and should extend below the base line by about half the upward distance. If the firing line is short or intermittent, or if the lower section does not appear, then there is an insulation breakdown in the distributor cap, plug leads, rotor or coil.

COIL AND CAPACITOR

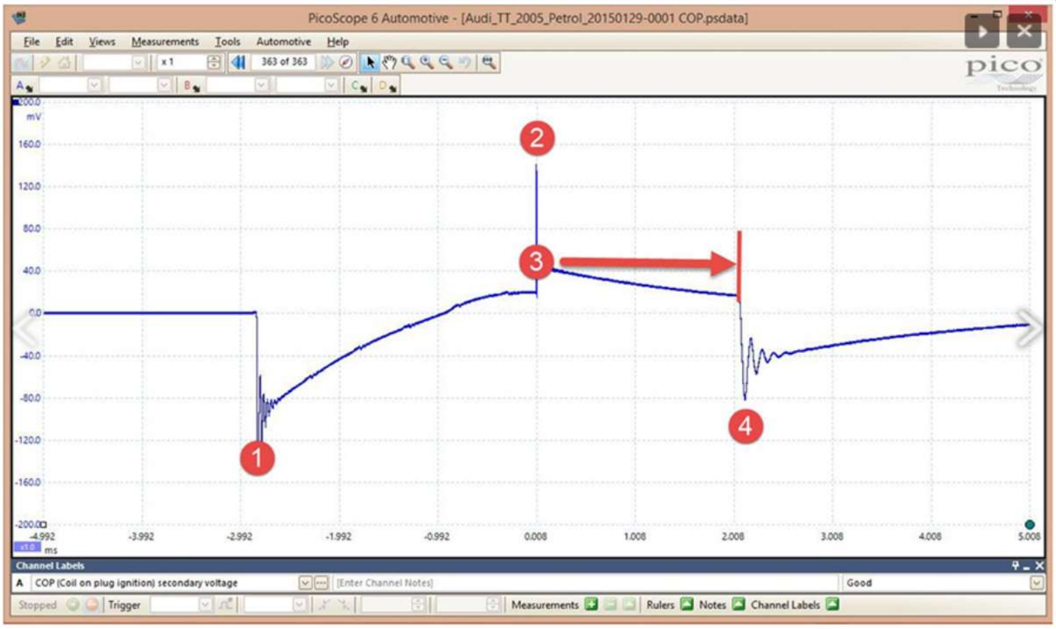
A series of diminishing oscillations should be observed at point D in the waveform. If these do not appear, or are truncated, there is either a shorted or crossed turn in the coil or the capacitor is breaking down.

BREAKER POINTS

Point E on the main waveform, or at the point opening position (A). Check breaker point action with the engine running at all speeds. Weak or incorrect breaker springs cause the points to bounce is readily seen on the scope. With very few exceptions, notably on some Citroens the high voltage side of a vehicle's ignition system is designed to have positive earth, regardless of overall vehicle battery polarity. The reason for this is that electrons are emitted more readily from a hot surface than a cold one so as a spark plug centre electrode always runs hundreds of degrees hotter than the side electrode the ignition system is devised so that a negative potential is, applied to the centre electrode. If this polarity is reversed, the plug will require an extra 5 kV or more to fire it, and that voltage may not be available from the coil under heavy load or when running at light throttle at high speed (remember a weak mixture needs a higher voltage to ignite it than a rich one). If you are checking polarity on a specialist ignition analyser then the polarity is correct if the pattern is as shown in the illustrations in this article. Polarity is corrected simply by reversing the coil terminals. (Incorrect polarity is usually caused by a mechanic replacing a coil intended for a negative earth vehicle with a coil meant for a positive earth vehicle, or vice-versa. It may also, but less probably, be caused by an incorrectly manufactured coil, or less likely, by the vehicle's polarity being accidentally reversed by the battery being connected the wrong way round).

MIXTURE STRENGTH

This section is intended for the lucky man who has access to an exhaust gas analyser and tachometer as well as a scope. If cylinder compression pressures are identical, plugs in good order and evenly gaped, and plug leads and distributor in good order, then any significant difference in firing line heights will almost certainly be caused by differing mixture strength from one cylinder to another. The voltage required to fire a rich mixture is substantially less than for a weak mixture: for instance a 12:1 ratio may need 3 to 4kV, whilst a 15:1 ratio may need 7 to 9 kV (typically). Thus even quite small differences in mixture strengths will be reflected quite dramatically in firing line height. The only accurate way to adjust mixture strength is as follows: Connect a tachometer to the engine and adjust slow running to 1000 rpm. Without looking at the gas analyser adjust mixture strengths so as to produce the highest tick over speed whilst maintaining the firing lines at an even height. If necessary reduce the tick over speed to keep it around 1000 RPM. Finally enrichen the mixture a shade until tick over speed drops by about 50rpm. Then and only then, look at the gas analyser. You should now have a reading somewhere between 14:1 and 15:1.If you haven't then there's something wrong with the carburetion system, an air leak in the induction manifold, incorrect float chamber level, blocked slow running jet or something.



Wave form as seen in PicoScope.

1. Negative polarity peak
2. Plug firing voltage – plug kV
3. Burn Time
4. Coil oscillation period