

Static Ignition Timing - General

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What is Covered:

The following document discusses the fundamentals of static timing automotive ignition systems. It was written specifically for the A- and B-series engines used in many British cars. It is applicable to other engines; however, the reader is advised that they (and not the author) are responsible for determining where the procedure differs for their vehicle. The discussion below will specifically address negative ground vehicles. The reader who owns a positive ground car must keep this in mind and compensate accordingly.

Also presented in this document are instructions on how to re-fit spark plug wires to the ignition system if they have been removed without marking them first, or where the distributor has been installed in a non-standard orientation.

What is not Covered:

This document covers ignition timing (when the spark is delivered to the spark plugs). This must not be confused with valve timing which is the positional relationship between the crankshaft and the camshaft which opens and closes the valves. This document will not tell you how to: 1) set your valves, 2) set/adjust your ignition points, 3) inspect ignition components. The reader must obtain this information from other sources.

Dynamic timing (where ignition timing is set with the engine running and using a timing or strobe light) is not discussed in this article.

Read and re-read this entire article before beginning any adjustments on your vehicle.

Glossary:

The text below (including the glossary) is written in U.S. English. The terms are fairly universal but the reader must confirm that they understand what is being described in each step. Regardless of the language used the procedure is universal.

- Static: Not moving, as in the engine is not running.
- Distributor: Spark plug wires are connected to an insulated cap on this device which routes (distributes) electricity from the ignition coil to the spark plugs. Below the distributor's insulated cap are electrical switching components such as points and a condenser, or electronic switching modules.
- Points: Electrical contacts inside the ignition distributor that open and close to supply and interrupt current flow to the ignition coil. Also called "ignition points".
- Condenser: A capacitor wired in parallel to the points to facilitate proper coil operation and limit arcing across the points.
- Coil: This is the short term for Ignition Coil, a device which when switched on and off behaves like a transformer to boost the car's 12 Volt electrical system to higher voltages to create the spark at the spark plugs.
- Rotor: This is a metal and plastic part located underneath the distributor cap. It attaches to the cam that opens and closes the points. The rotor directs electricity from the center of the distributor cap to each of the spark plug wires.
- Low-Tension: This is the low-voltage side of the ignition system. It operates at (or near) 12 Volts DC.
- High-Tension: This is the high-voltage side of the ignition system. Components associated with the high-tension circuit include the ignition coil, distributor cap and rotor, spark plug wires, and the spark plugs.
- TDC: This is the acronym for "Top Dead Center". This refers to the position where a piston is at the very top of its stroke (the top of the piston will be near the top of the engine block).
- BTDC: This is the acronym for "Before Top Dead Center". This refers to the angular position of the engine crankshaft at the time the spark plug needs to fire to ignite the fuel/air mixture.
- Backlash: Looseness or play between mechanical components, such as a timing chain that is tight on one side of a sprocket and loose on the other. Here it refers to play associated with the mechanical components of the ignition system.
- Four-Cycle: This refers to the common combustion cycle in most gasoline powered automobile engines. In this process there are four steps or cycles requiring two complete engine rotations for completion. These steps are: Intake (piston moving down and drawing in the fuel/air mix), Compression (piston moving up and squeezing the fuel/air mix), Combustion (piston driven down by the burning fuel/air mix), and Exhaust (piston moving up to push out the burned fuel/air mix). The static timing is set when the piston in cylinder #1 is slightly before TDC at the end of the compression stroke.
- CW & CCW: These are acronyms for "clockwise" and "counterclockwise" respectively.
- Ground: Automotive electrical systems connect one terminal of the car's battery to the car's chassis. The car's chassis is referred to as the "ground" or "earth" connection.

Tools Required:

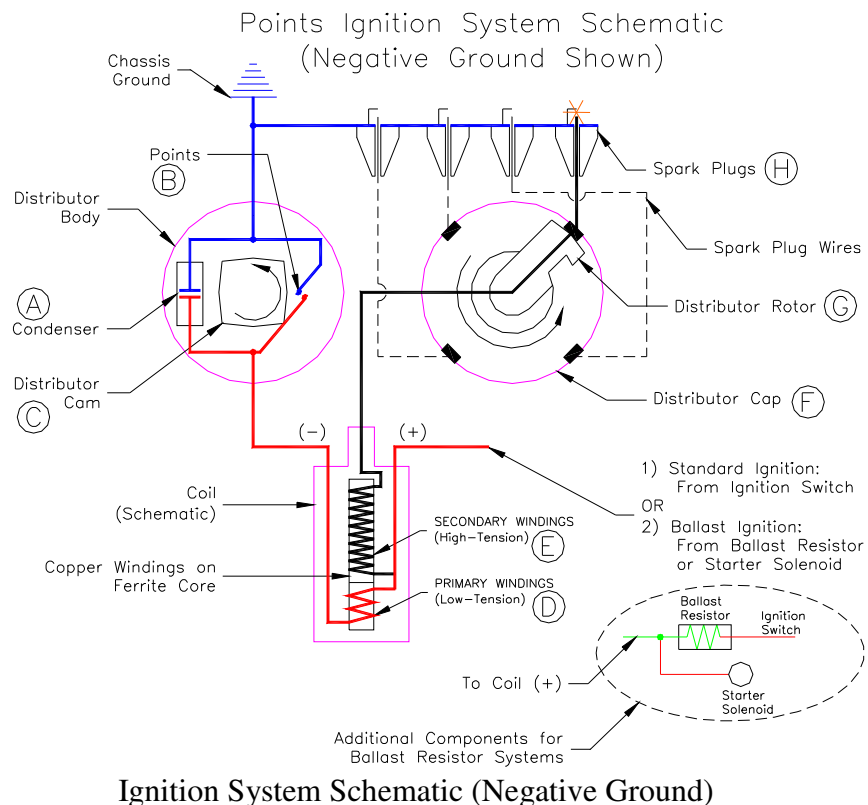
- Test Lamp:** This is a device made by connecting two wires to a simple automotive light bulb. One wire connects to the contact tip of the bulb, the other to the metal shell of its base. When the two wires are connected across a 12 Volt supply the bulb lights to indicate power is present.
- Multi-meter:** Electrical volt/ohm meter. This is optional and can be used in place of the test lamp to determine when 12 Volts is present.
- Wrenches:** The distributor will be clamped to the engine block. It will be necessary to loosen the distributor clamp to rotate the distributor and adjust the timing.

Theory of Operation:

In the discussions that follow, all electrical polarity mentioned is for negative ground cars.

A basic understanding of the coil and its operation is necessary to understand what is to be achieved in static timing. The figure below shows a simplified schematic of the Kettering ignition system using points and a condenser. In electronic ignitions an electronic module replaces the points and condenser but serves the same function. Succinctly, when the coil is supplied battery voltage on its (+) terminal AND the ignition points in the distributor are closed, current flows through the ignition coil to chassis ground. This creates a magnetic field inside the coil. As the crankshaft in the engine rotates, it turns a cam inside the distributor (at 1/2 engine speed). The cam in the distributor opens the points and disrupts current flow through the coil. When the current stops flowing through the coil, its magnetic field collapses and this creates a high voltage spike on the coil's high-tension or secondary windings. The high voltage spike is delivered via the rotor, distributor cap, and spark plug wires to the appropriate spark plug.

For the engine to run efficiently and develop the proper power, the spark must occur at the right time. This is controlled by adjusting the position at which the cam in the distributor opens the points relative to the position of the crankshaft (the distributor body position is adjusted so the points open at the correct crankshaft position). Most engines (for reasons beyond the scope of this document) require the static ignition timing be set so the ignition points open several degrees before the piston reaches top dead center (BTDC). Setting the static timing is a simple task but care needs to be taken when making these adjustments that they are being carried out for the correct cylinder at the correct step in the four-cycle process. (Typically this is with cylinder #1 several degrees BTDC on the end of the compression stroke).



Preliminary Adjustments:

Various maintenance steps need to be carried out before adjusting the ignition timing. Before proceeding the reader must carefully dress (or replace) and set the gap of the points. The reader must also inspect all the ignition components replacing any that are suspect.

Prior to proceeding, remove the distributor cap and have an assistant turn the engine over on the starter. Observe and record the normal direction of rotation for 1) the engine, and 2) the rotor in the distributor. The A-series and B-series engines have clockwise (CW) crank rotation when looking at the front (radiator fan end) of the engine and their distributor rotors turn counterclockwise (CCW) when observed looking straight down on them. On A- and B-series engines #1 cylinder is closest to the radiator fan.

NOTE: Any mention of rotation direction in subsequent paragraphs refers to what is standard on British A- and B-series engines. The reader **MUST** note where this is different from their car and adjust the steps accordingly.

Timing Sequence:

Check service manuals to determine what settings are appropriate for your vehicle (static timing settings, firing order, and location of timing marks).

Timing specifications are typically given in degrees BTDC for the #1 cylinder (or spark plug). Therefore the reader needs to correctly identify which cylinder is #1 and that it is near (but before) TDC at the end of the compression stroke before proceeding. This can be determined several ways. When in doubt, the best method is to remove the valve cover and inspect the valve rocker arms for cylinder #1. When the piston is near TDC on the firing stroke, the piston should be visible through the spark plug hole and its rocker arms will be loose, indicating that the valves are fully closed and that cylinder is ready to fire. If the crankshaft is rotated one more full turn, the piston will again be near TDC, however, this time the rocker arms will be tight (valves open) indicating that the engine is at the end of the exhaust stroke and ready to begin an intake stroke. **The reader is advised to confirm that the engine is near TDC at the end of the compression stroke before making any changes to the ignition settings.**

To static time the engine perform the following steps:

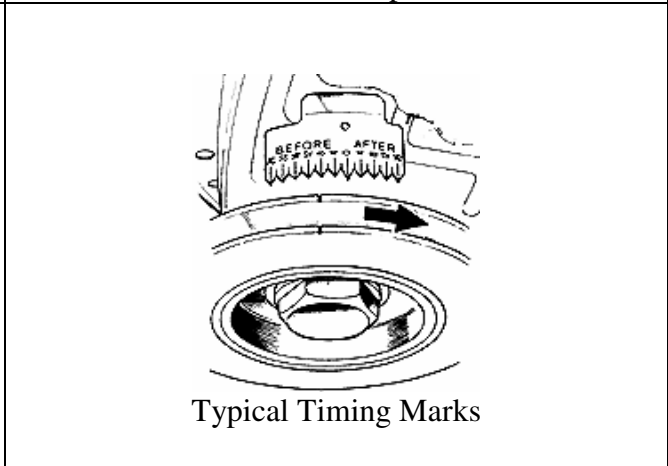
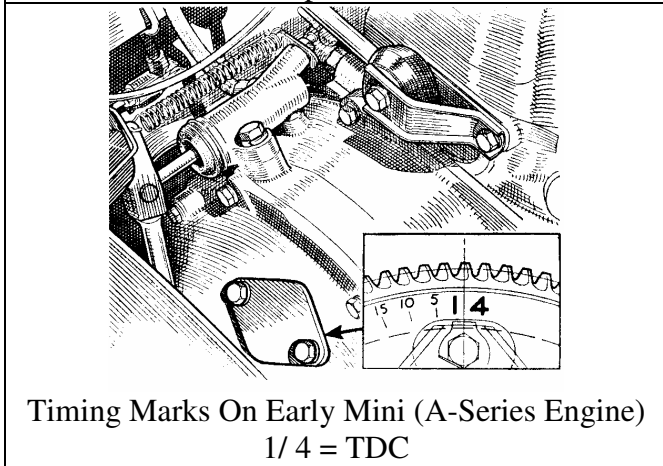
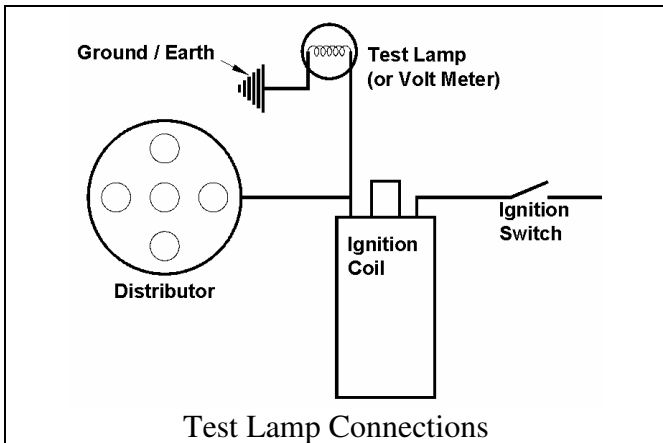
1. Label the spark plug wires, remove them from the spark plugs then remove the spark plugs.
2. Remove the distributor cap from the distributor but leave the spark plug wires attached to it.
3. Locate the timing marks on your engine and determine which are correct for your use.
4. Use one of the following methods to turn your engine over as works best for your car:
 - Put the car in neutral and pull the engine over using the tight fan belt and fan, or
 - put the car in gear and jack the car up sufficiently to elevate one drive wheel then rotate the elevated wheel, or
 - leave the car in gear on level ground and roll the car to turn the engine over, or
 - with the gearbox in neutral, use the appropriate socket on the crank pulley and turn the engine over using a wrench.
5. Turn the engine only in the normal direction of rotation and stop turning the engine when the desired timing marks come into alignment. (i.e. Stop at 5 to 8 BTDC on A-series engines). If you overshoot the desired timing mark, back up past the desired mark by at least 30 degrees, then move forward again to assure that all the slack and backlash have been taken out of the mechanical components. Remember that you must stop at the timing marks when the piston is near the end of the compression stroke.
6. Locate the wire connecting the distributor to the coil. Connect your test lamp (or multi-meter) wires between this coil terminal and a good, bare metal earthing (ground) spot on the engine or car body.
7. For reference, make a small removable paint mark between the distributor body and the engine. (In the event of some unforeseen problem, the distributor can be set to its original position by re-aligning the paint marks).
8. Loosen the distributor clamp.
9. Switch ON the ignition (Pertonix/Aldon Ignitor owners read the appendix first). The test lamp may be OFF or ON.

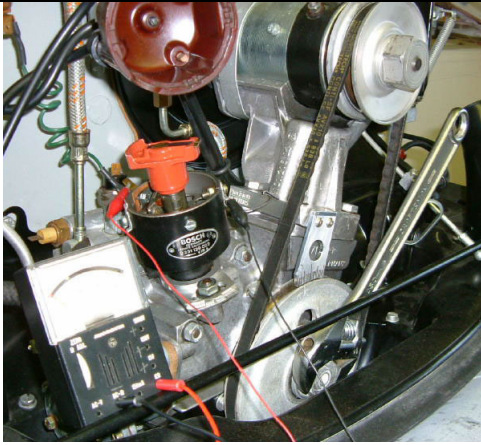
10. If the test lamp is ON, turn the distributor body SLOWLY in the direction you observed the rotor turning during normal engine rotation until it turns OFF, then continue about 10 or 20 more degrees. If the lamp was already OFF, turn an additional 10 to 20 degrees in the direction of rotor rotation and stop.
11. SLOWLY turn the distributor body back in the OPPOSITE direction you just turned it until the test lamp just turns on. You will be turning the distributor body the OPPOSITE direction of rotor rotation.
12. Stop immediately when the test lamp turns on and tighten the distributor clamp.
13. Refit the rotor (if removed), distributor cap, spark plugs, and refit the spark plug wires.
14. Once you have started the engine and are happy with the results, remove the old paint alignment made in step 7 above and make a new paint mark between the distributor and engine block.

NOTES:

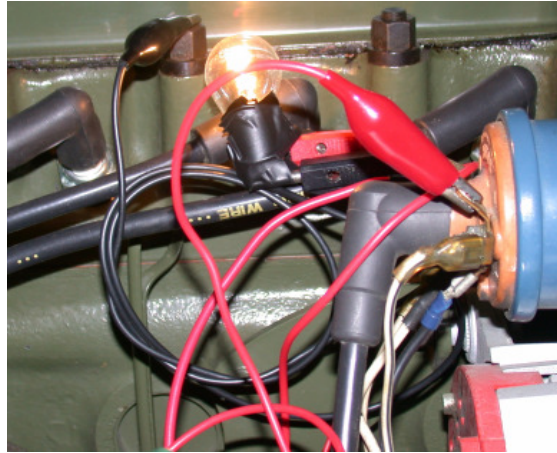
1) The test lamp will turn ON when the points are open and OFF when they are closed. When you turn the distributor body until the test lamp just turns on (or multi-meter displays 12 Volts) you have located the point where the coil will fire to create the spark. Locking the distributor down in this position sets the static timing for the engine.

2) IF you find you have to reset the timing on the side of the road and cannot improvise a test lamp, timing may be carried out by eye. As above, turn the distributor body in the direction of rotor rotation until you see the points are fully closed. Stop and turn the distributor body SLOWLY in the opposite direction watching closely for a small spark at the points which indicates the exact moment that they open. This is equivalent to the test lamp turning "ON".





Multi-meter connected to VW (in place of test lamp) for static timing. 12V = Points open. Distributor rotor is the light-brown component above the black, cylindrical distributor housing.



Test Lamp between coil (-) and ground. (Red wire on coil (-), Black wire on cylinder head stud). Points are open.

Firing Order:

For various reasons a distributor may have been inserted into an engine block in a “non-standard” orientation. For this reason the spark plug wires may be arranged on the cap in positions that differ from what is shown in service manuals. This is not a serious problem. What is important is the firing order. (**Air cooled VW owners please see the appendix. Distributor orientation and spark plug wire placement is important to you**).

If the reader has followed the steps outlined in “Timing Sequence” above, they have identified when #1 cylinder is at the top of its compression stroke. Subsequent to that they have set the static timing for #1 cylinder. Installing the spark plug wires in the correct sequence is a simple extension of that process.

If the engine ran properly before (and the spark plug wires have not been removed from the distributor cap) simply re-fit the rotor (if removed), the distributor cap, and spark plugs, then reconnect the spark plug wires to the spark plugs. There is nothing to change.

If for some reason all the spark plug wires were removed or the spark plug wires were not marked prior to removal, proceed as follows:

1. Complete the Timing Sequence described above. (Do not turn the engine after setting the static timing).
2. Fit the rotor to the shaft/cam inside the distributor if it was removed.
3. Fit the distributor cap to the distributor making sure it engages any alignment features that orient it correctly.
4. Remove the cap again, pulling it slowly straight up.
5. The rotor will be pointing in the direction of a lug and spark plug wire on the distributor cap. Place the spark plug wire for #1 cylinder on that cap lug/position and connect its other end to the spark plug for #1 cylinder.
6. Refer to your service manual and find the firing order for your engine. (For the A- and B-series British engines the firing order is 1-3-4-2).
7. Refer to your notes where you recorded the direction of rotor rotation.
8. Sequentially put the spark plug wires on the distributor cap following the direction of rotor rotation and the firing order listed in your service manual. For the A- and B-Series engines the direction of rotor rotation is counterclockwise and the order is 1-3-4-2. Therefore, after fitting the spark plug wire for #1 cylinder to the distributor cap, the next lug CCW on the cap receives the spark plug wire for cylinder #3 and so on.

Again, your service manual may show the distributor oriented a different way than you find on your engine and this may have occurred for several reasons. However, if you were able to static time your car's ignition, and if any vacuum advance tubing for the distributor is long enough, and if the spark plug wires are long enough to reach the appropriate spark plugs there is no problem with rearranging your spark plug wires around the distributor cap as long as the firing order is maintained.

Appendix:

1) Pertronix/Aldon Ignitor:

There are at least two versions of electronic ignition modules available from Pertronix. The original module (simply referred to as an Ignitor) can be static timed exactly the same as ignition points. HOWEVER, the ignition module is not rated for continuous passage of current. **Limit the time power is flowing through the Ignitor unit to less than three minutes**, then allow an equal time for cooling before applying power again. Removing power can be addressed by turning the ignition off between attempts to static time the engine.

A later version of this module is referred to as Ignitor II. This module CANNOT be static timed.

Older Crane/Alison ignitions can be static timed following the procedure above but the author is not familiar with later units, nor is the author familiar with Lumenition ignitions.

2) Air Cooled Volkswagen Engine Firing Order:

Unlike most engines, the air cooled VW has an asymmetrical distributor cam. The distributor is intentionally designed to provide slightly different timing for cylinder #3. This altered timing is provided to account for the higher operating temperature of cylinder #3 due to the proximity of the engine oil cooler. VW owners should pay close attention to and adjust their distributors to match the installation and firing order photographs shown in their service manuals.

Rev	Date	Changes