Timing a HEI Distributor

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To set the timing on a Chevy 350 small-block engine, you can:

- Rotate the engine to top dead center (TDC) on the compression stroke of the #1 cylinder
- Attach a degree wheel to the crankshaft and set it to zero
- Turn the crank backward until the degree wheel reads 10 degrees before top dead center (BTDC)
- Align the distributor rotor with the cap location for the #1 spark plug wire

A good rule of thumb is to set the timing at 12 degrees advance after starting the engine for the first time. However, the total advance should be limited to around 36-37 degrees.

unplug the vacuum hose if there is one, get a timing light with a dial or digital readout, and the see what the timing is when you rev the engine up enough that the timing won't advance any more (probably around 2000- 3000 rpm or so). Should be set to somewhere around 34 degrees on a 350 with older design heads, maybe a bit less for the modern heads.

SBC's normally run 32-34 degrees total Mechanical advance. Should be "all-in" by about 2,500-3,000 RPM's. Disconnect and plug the vac. advance line, hook up a timing light and read the timing while you or a friend opens the throttle a little. Check to see what your total timing is when it's fully advanced. Adjust to the aforementioned 32-34 degrees. Also record the RPM's at which it stopped advancing. If it's way higher than the 2,500-3,000 start trying lighter advance springs to get it down in that range. You will probably end up with 8-10 degrees at idle, but the important is not the idle timing...it's the fully advanced total as well as the "advance curve"...ie: the rate that it will advance as RPM's increase.
-Scott

1.) Plug vac. adv. line.
2.) Hook up timing light
3.) Read the timing while you increase RPM's until it stops advancing...record that RPM.

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4.) Observe the total advance and adjust to 32-34 degrees (keep the RPM's up while doing this).
5.) Only mess with the advance springs if it took more than about 2,500-3,000 RPM to come in totally.
6.) Don't worry about your timing at idle. Just hook up the vac. advance when you're finished and that's it.

Modify Timing Curve

How do I find my total timing number?
What is my distributor's timing curve?
Total time = Base timing + Mechanical timing + Vacuum Timing
Use lighter springs to advance at lower RPM's.
My engine needs more advance at idle but not too much at the upper end, shorten the timing curve
Timing line on spark plug, at full advance???
Place the idle at the highest vacuum – set the distributor to get the highest sounding idle. What is the timing – use timing light
Trying to find out how little advance to run on bottom end and engine still be happy
Changing springs determine when to get the0 advance, heavier springs delays timing advance
Heavier springs advance timing slower RPM
Lighter springs advance timing faster vs RPM
Rus as aggressive a curve as you can just shy of spark knock
Advance timing as fast as you can but shy of spark knock.

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How to Set Ignition Curves and Create Optimal Performance

HOT ROD Staff Writer

Ignition timing is easily the single most important tuning adjustment on an internal-combustion engine, yet the concept of ignition curves continues to be elusive for many enthusiasts. All it takes to improve torque, horsepower, and driveability is a simple timing light and an informed tuning process. Think of this as "free" horsepower, because it costs very little to optimize timing as long as you know the tricks.

The plan behind optimized ignition timing hasn't changed since Nikolaus Otto began fooling around with four-stroke, internal-combustion engines in the 1870s. The idea is to light the

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charge in the cylinder with enough lead time (advance) to create maximum cylinder pressure at the ideal point after top dead center (ATDC) to push the piston down, exerting leverage on the crank. It's generally acknowledged that peak cylinder pressure needs to occur at roughly 15 to 18 degrees ATDC to maximize leverage on the crankshaft. If the spark timing is too early, the cylinder may experience detonation and potentially cause damage.
If the spark occurs too late, the engine runs flat, makes less power, and may overheat. For a typical distributor-equipped street engine on pump gas, this means we should take the Mama Bear approach to ignition timing. This discussion will focus on street-driven engines running pump gas, although the generic components are all the same for any engine.

An engine's ignition-timing requirements will vary, depending on dozens of variables like compression ratio, fuel octane, combustion-chamber shape, and inlet air temperature to name a few biggies. But condensing this down to its simplest aspects, timing is dependent on engine speed and load. Load is determined by the throttle and is easily monitored with a vacuum gauge. When the throttle is barely open, the engine demands more air than the throttle allows, creating manifold vacuum (low pressure). A typical street car with a mild cam might idle at 12 to 16 inches of mercury (in-Hg) on a vacuum gauge. As the throttle is opened, manifold vacuum begins to drop. At wide-open throttle (WOT), manifold vacuum drops to near zero. Most engines will pull roughly 0.5 in-Hg of manifold vacuum at WOT.

The next step is to separate ignition timing into three basic components: initial timing, mechanical advance, and vacuum advance. Our approach with this engine is to optimize the spark timing over the engine's entire operating range while minimizing the chance of detonation.

All this starts with initial timing. This is the amount of advance at idle with the spark triggered before top dead center (BTDC). Most stock street engines call for 6 to 8 degrees of initial advance, but this is not set in stone. Engines with longer-duration camshafts and other modifications often demand more initial timing. It's not unusual to input 14 to perhaps 18 degrees of initial timing for engines with big cams. This timing is checked with a timing light that compares the position of the No. 1 cylinder TDC mark on the harmonic balancer with a timing-reference tab located most often on the timing-chain cover. Initial timing is set by loosening the distributor hold-down bolt and rotating the distributor body. This changes the relationship between the distributor body and the spinning rotor. Twisting the distributor opposite to the direction of rotation advances the initial timing.

Next is mechanical advance. Mechanical advance is tied strictly to engine speed (rpm). Mechanical advance is determined by a centrifugal advance mechanism, first used on James Watt's steam engines in the 1780s. But even Watt admits he borrowed the idea from an earlier design that appeared on a 1600s gristmill.

The typical centrifugal advance uses a pair of weights that pivot on pins. The weights are attached to a plate that locates a pin moving within a fixed slot. The distance the pin travels is the amount of mechanical advance, accomplished by advancing the position of the rotor. On a typical Chevrolet distributor that spins clockwise, as the mechanical advance weights open, this moves the rotor in the same direction, advancing the timing. The rpm at which the weights begin

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to move and the point of their maximum travel is determined mainly by the strength of the springs that hold the weights in place. Lighter springs allow the advance to begin at a lower rpm. Heavier springs delay the onset and slow the rate of advance.

A typical mechanical-advance curve might start advancing at 1,500 rpm and achieve full advance by 2,600 rpm. If that full advance moves the rotor by 25 crankshaft degrees and our initial timing is set at 10 degrees BTDC, then our total mechanical-advance reading at the harmonic balancer at 2,600 rpm or higher would be 35 degrees (10 initial + 25 mechanical = 35 degrees total). We can adjust this total by either adding or subtracting initial or mechanical advance. Changing the quantity of mechanical advance requires modifications to the slot or by changing the bushing diameter that fits over the pin in the slot. Both of these methods change the physical amount of space the rotor can move.

It's important to mention that checking the mechanical advance with a timing light should always be done with the vacuum-advance canister disconnected. If the canister is not disconnected, the readings will be a combination of initial, mechanical, and vacuum advance.

Now we can introduce vacuum advance into this system. There's a popular but misguided view among enthusiasts that vacuum advance is only for bone-stock engines and/or emissions-controlled engines. The more enlightened way to look at vacuum advance is to view it as load-based timing. It's worth a peek down the rabbit hole of the combustion process to understand why load-based timing is important.

Let's use the example of a typical carbureted small-block cruising down the freeway at 70 mph at 2,800 rpm on level ground. The engine could be pulling anywhere from 14 to 18 inches of vacuum. As mentioned before, high vacuum means low load and a nearly closed throttle. A little-known fact is that most mild street engines cruise down the freeway pulling fuel from the carburetor's idle circuit. That's not a misprint. Engines with long-duration cams or cars with tall gears in overdrive might transition into the main circuit, but most mild street engines with high vacuum at cruise will actually be running on the idle circuit.

With a minimum of air and fuel entering each cylinder, this means the mixture is not tightly packed. Here's where things get tricky: You may have always thought of the combustion process as an explosion—the spark goes off and,, combustion occurs like a bomb. That's not what happens. The reality is the spark plug fires and it takes a generous period of time for the combustion gases to burn completely across the top of the piston—much like a prairie fire across a large valley. The more densely packed the grass is, the faster it burns, while sparse areas burn more slowly.

We can apply this prairie-fire analogy to the combustion space. At WOT, the air and fuel are tightly packed and burn quickly, so we don't need as much timing. At 2,800 rpm at WOT, 32 to 34 degrees of timing could be just about perfect for a typical pump-gas street engine. However, at very light throttle (14 to 16 inches of manifold vacuum), the air and fuel are far less densely packed in the cylinder. To make the most power possible at part throttle, we need to start the

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combustion process much sooner—perhaps as much as 40 to 44 degrees BTDC, depending on the engine's individual demands.

This much timing is only needed when the engine is under very light load. Since manifold vacuum is a great indicator of load, early engine designers used a small vacuum canister attached to the distributor to advance the timing under high manifold vacuum to create a load-based timing curve independent of mechanical advance.

The two graphs illustrate very simple mechanical and vacuum advance curves. Mechanical advance is totally dependent on engine speed, while vacuum advance is controlled only by engine load. We need both because on the street we can have low load at very high engine speeds, say 6,000 with the throttle barely open or very high load (WOT) at very low engine speeds like 1,500 rpm. These two situations have very different ignition-timing requirements.

Now let's introduce the critical variable of cam timing. Let's use an extreme example with a small-displacement engine like a carbureted Ford 5.0L with a big hydraulic roller cam with 230 degrees of duration at 0.050-inch and 0.565-inch lift. Even with 16 degrees of initial timing, let's say our engine barely idles at 8 inches of manifold vacuum, and it's backed by a tight torque converter because it also has nitrous.

Even with 9.5 or 10.0:1 compression, the application of a big camshaft means the cylinder pressure at low speeds will be greatly reduced compared to a milder cam. This engine would respond to more vacuum advance at cruise speeds at part throttle to improve its driveability and throttle response. Our experience shows that connecting the vacuum advance to a manifold vacuum source will add timing and help the engine idle better in gear with an automatic transmission. Milder applications can also benefit from this idea, but will require some experimentation. Several companies like Crane, Moroso, Pertronix, and Summit Racing offer adjustable vacuum-advance canisters that allow you to customize the advance curve to fit your engine's requirements.

Let's put these ideas into action with a specific example. We dropped a very mild 383ci small-block into an early El Camino pushing through a TH350 trans and a very tight 11-inch converter. With 16 degrees of initial timing and a properly adjusted idle circuit in the Holley carburetor, the engine struggled to idle with the in-gear vacuum dropping to below 8 in-Hg. Adding more initial timing meant making major changes to the HEI distributor to limit the mechanical advance that was ideal at 20 degrees advance (16 initial + 20 mech. = 36 degrees total).

The distributor was fitted with an adjustable vacuum-advance canister, so we connected the can to manifold vacuum, which added 14 degrees of advance and created 30 degrees of advance at idle. The idle vacuum instantly improved to 12 inches in gear and allowed us to lower the idle speed to minimize that annoying in-gear clunk. The added vacuum advance also allowed us to further lean the idle mixture slightly. This engine only had 8.5:1 compression, so it prefers more timing. After additional driving and tuning, we finalized this combination with 14 degrees initial, 20 degrees of mechanical advance, and 14 degrees of vacuum advance for 48 degrees at highway cruise speeds, yet it runs fine even with 87-octane fuel.

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Every engine will have different timing requirements based on its combination of combustion-chamber design, compression, octane, cam timing, and ignition-curve variables. The best way to determine your ideal curve is to make small changes and evaluate them for a few days of driving before attempting further changes. Pay attention to what your engine is telling you and record all your changes in a notebook.

This is just one example, but it serves to illustrate how you can juggle ignition timing to improve part-throttle engine performance. Very few magazine stories talk about part-throttle performance, but it's critical for street-driven engines. If you think about it, a street engine easily spends 95 percent of its life at part throttle and idle. Why wouldn't you take the time to ensure your engine runs its best where it will be spending nearly all of its operating life? Spend a little quality time with your engine and a timing light, and we guarantee you will be glad you did.

Factoid

Optimizing ignition timing at part throttle usually results in a cooler-running engine. Late ignition timing exposes more of the cylinder wall to the combustion process, which puts more heat into the coolant, so the engine runs hotter.

This is a typical mechanical-advance mechanism on an HEI distributor with a pair of weights that move outward as engine speed increases. You can create a custom curve by mixing springs from an aftermarket spring kit. One of the two slots is indicated by the arrow. The only way to reduce the total mechanical advance is to shorten the length of the slot. This will require disassembly and some brazing or welding.

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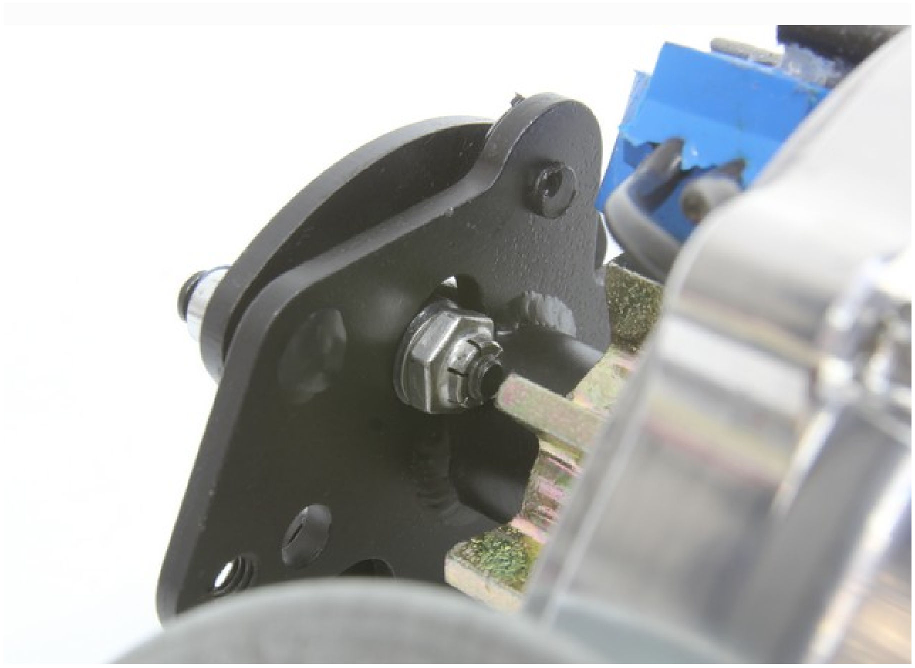

MSD distributors use a single slot and pin with a bushing that is retained by a nut. Changing the bushing diameter allows the tuner to increase or decrease the amount of mechanical advance. MSD distributors come with the largest (black) bushing that minimizes the mechanical advance, but smaller bushings are supplied with the distributor. Make sure to put as spot of Loctite on the threads when changing the bushing. We've seen these nuts fall off.

Vacuum-advance canisters move the plate in the distributor when vacuum is applied to the internal diaphragm. Vacuum applied to the diaphragm advances the pickup position, altering the timing. Adjustable vacuum canisters are available for most popular distributors and are usually identified by their octagonal shape. This one uses a 3/32-inch Allen wrench to adjust the rate at which advance is applied.

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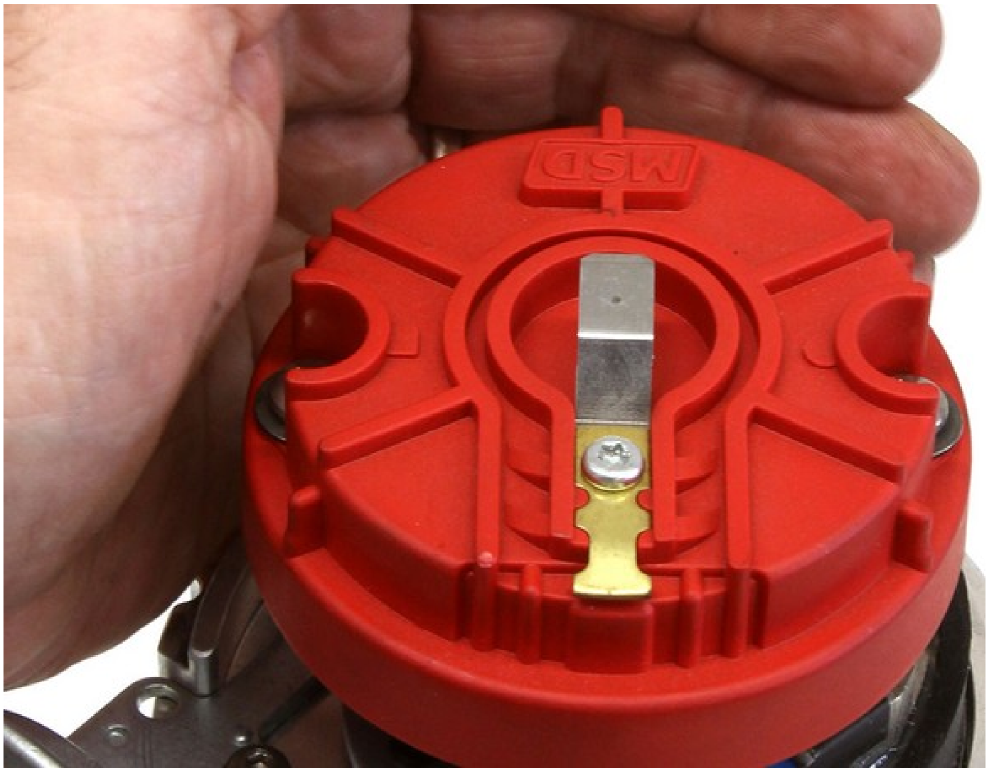
This Innova digital, dial-back timing light displays the total advance (32 degrees) and engine rpm (2,580). To use this dial-back light, press the advance (up arrow) or retard (down arrow) buttons until the TDC mark lines up with the zero mark on the engine's timing tab. This display then tells us we have 32 degrees of advance at 2,580 rpm.



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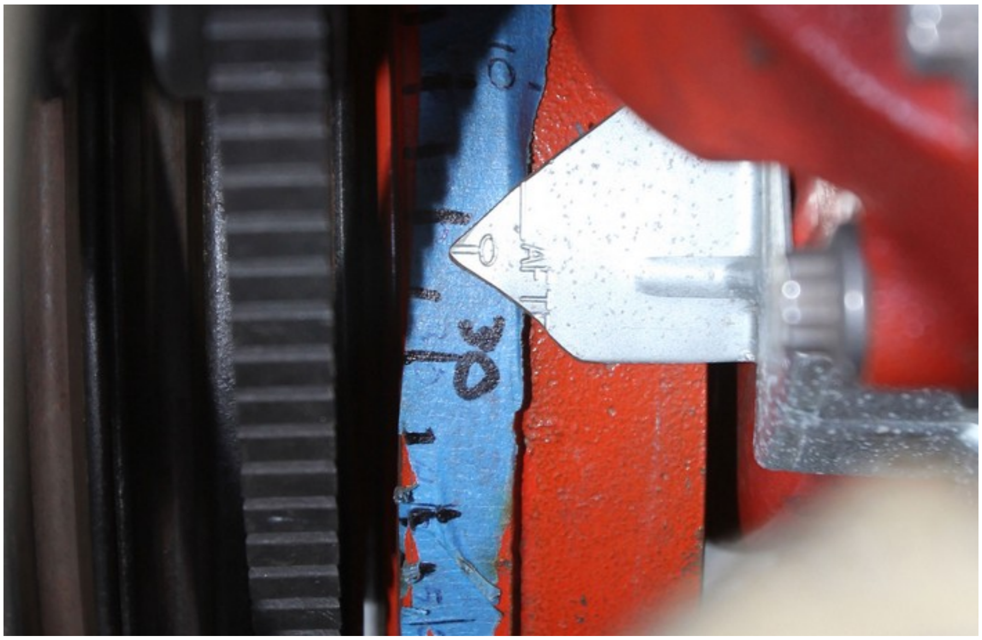
Here's a quick tip for determining rotation on any distributor with a vacuum-advance can. Position your hand parallel with the vacuum-advance can as shown. Your fingers will point in the direction of distributor rotation. This Chevrolet HEI distributor rotates in the clockwise direction. Ford distributors locate the vacuum can on the opposite side of the housing, which means they rotate counter-clockwise. Simple, no? You can buy a timing tape from MSD that will



display the timing marks so you don't need a dial-back light. Or you can make your own tape as we've done here. Multiply the balancer diameter by 3.1417 (pi) and divide that value by 180 to get a distance per 2 degrees. For an 8-inch-diameter balancer, we rounded that 2-degree value to 0.140 inch. That positions the 30-degree mark at 2.1 inches from the zero mark on the tape.

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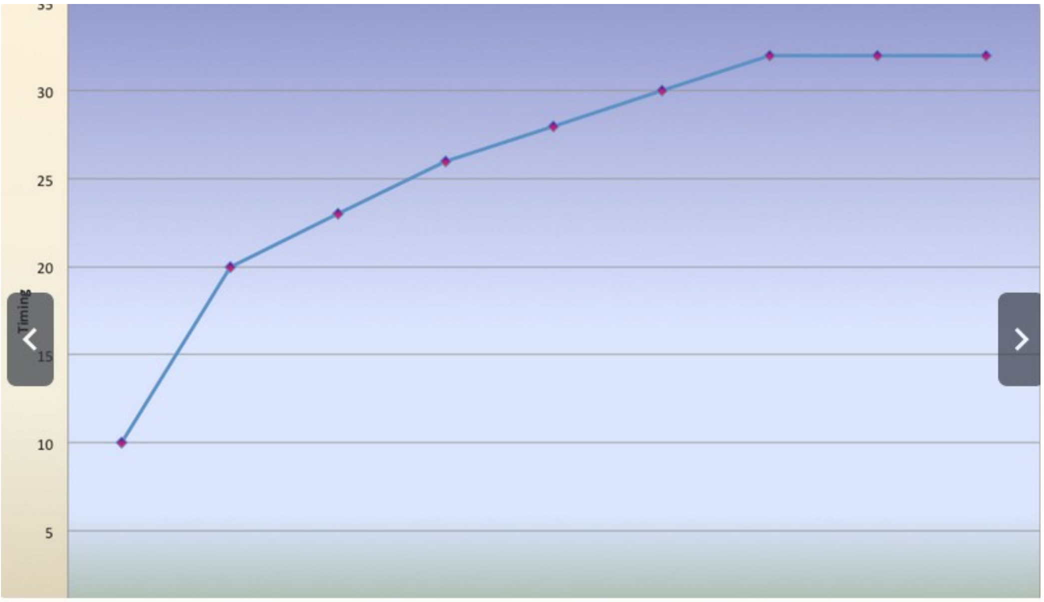
All this tuning assumes the ignition system is already in peak condition. Always use a high-quality distributor cap with brass connections like this MSD piece instead of the cheap aluminum ones and spend the money on quality spark-plug wires.

Even the little things can make a difference. Projected nose spark plugs (left) move the spark a little closer to the middle of the chamber and offer a small advantage over standard plugs (right).



Graph A illustrates a typical mechanical-advance curve that includes the initial timing of 10 degrees with a total of 32 degrees. This equates to a mechanical advance of 22 degrees. Graph B reveals a vacuum-advance curve adding as much as 14 degrees of additional timing at 18 in-Hg. Combining these two curves, it's possible to have as much as 46 degrees of advance at a 3,000 rpm cruising speed if the manifold vacuum is at or above 18 in-Hg (32 + 14 = 46).

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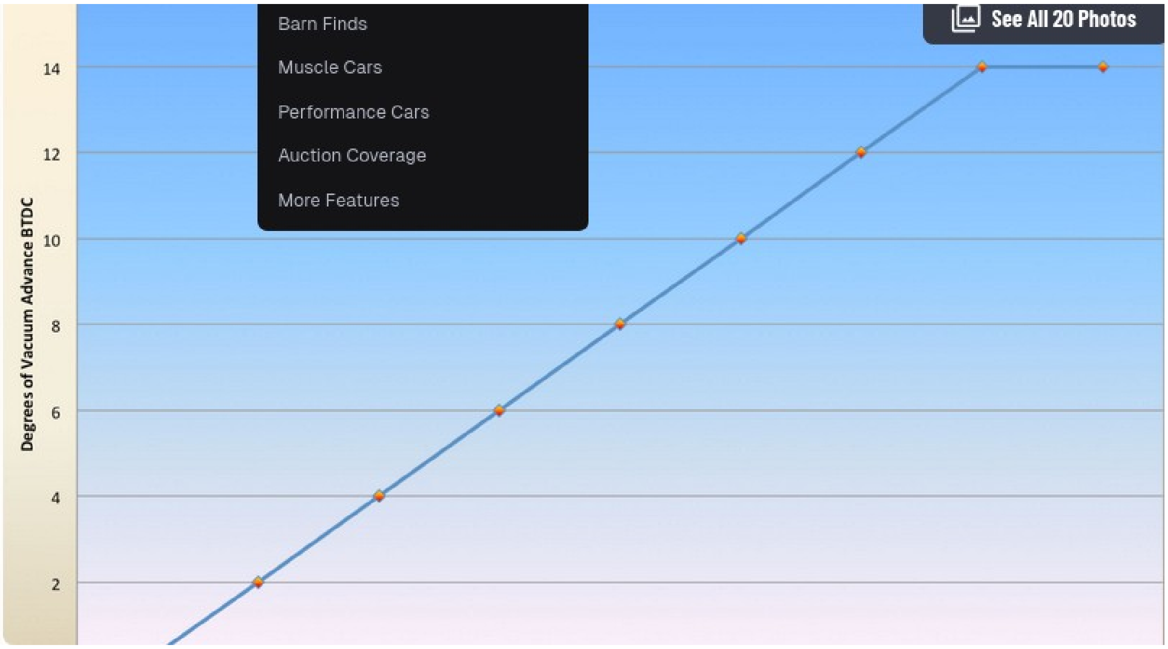

5.3L LS Timing vs. Load Map

Load (Throttle Percentage)	1,000	2,000	3,000	4,000	5,000	6,000
10%	40	50	53	52	49	44
20%	32	34	38	40	36	32
30%	24	28	31	33	32	30
40%	18	25	28	32	31	29
50%	10	16	21	26	29	29
60%	4	12	17	26	28	28
70%	-11	8	14	26	28	28
80%	-11	6	14	26	28	28
90%	-11	6	14	26	28	28
100%	-11	4	14	26	28	28

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If you refer back to the two graphs, you will notice they are both linear (straight-line) curves. Electronically controlled engines offer the advantage of non-linear-based ignition curves because the digital design allows finite control of the ignition timing. This chart is a simplified example of a load-based timing map that originated from an 87-octane GM 5.3L LS truck engine. This map is essentially a combination of initial, mechanical, and vacuum advance. The vertical scale is the percentage of throttle opening (load) while rpm is presented on the horizontal scale. As you would expect, as load increases, timing decreases. As an extreme example, you would never be at WOT (100%) at 1,000 rpm, but if this did occur, you can see the map minimizes the timing to -11 degrees, which is 11 degrees ATDC, which is drastically retarded to prevent detonation. Conversely, at 10-percent throttle opening at 3,000 rpm, the timing is at 53 degrees. That's a spread of 64 degrees.

Parts List

Description	PN	Source	Price
Innova electronic dial-back timing light	3568	Summit Racing	$89.97
Crane HEI adjustable vacuum can and springs kit	99600-1	Summit Racing	$35.40
ACCEL HEI adjustable vacuum canister	31035	Summit Racing	$26.23
Pertronix HEI adjustable vacuum canister	D9006	Summit Racing	$24.97
Summit HEI adjustable vacuum canister	850314	Summit Racing	$12.97
Standard Motor SB Ford adjustable vacuum canister	VC192	Summit Racing	$42.97
Summit LA Mopar adjustable vacuum canister	850426	Summit Racing	$19.97
Crane GM points dist. vacuum advance can and kit	99601-1	Summit Racing	$35.43
MSD timing tape	8985	Summit Racing	$4.58

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High energy ignition

High energy ignition, also known as **H.E.I.**, is an electronic ignition system designed by the Delco-Remy Division of General Motors. It was used on all GM vehicles, at least in the North American market, from 1975 through the mid-1980s.[*vague*] The system is an electronic system that requires no scheduled maintenance, provides up to 35,000 volts to fire the spark plugs and increase spark plug life, especially when unleaded fuel is used. The HEI system has 40% more voltage output and 85% higher energy level than conventional breaker point systems to fire lean fuel mixtures even under adverse conditions.

There were many design variations over the years, and provisions for computer controls were added for some applications starting in the late 1970s. A predecessor system called "Unitized Ignition" was optional on 1972 and 1973 Pontiacs. [*citation needed*]

Most—but not all—HEI systems have the ignition coil mounted in the distributor cap. A control module and magnetic pickup are mounted in the distributor, in place of a conventional ignition system's breaker points and condenser.

Description

The HEI system was developed as an integrated package that combines the distributor, magnetic pick-up, ignition coil and electronic module into one package. By doing this, these components are well protected from physical and environmental abuses and the number of electrical connections are reduced.

There are some models that use a remotely mounted coil. This coil is constructed the same as the integral coil with the exception of a mounting bracket and a terminal for the connection of a high tension lead. These models are used on engines where additional clearance was needed.

The size of the distributor was increased due to the wide spacing that must exist between the' distributor cap Inserts to prevent high voltage arc-over. A wider spacing was also needed between the cap, inserts and the distributor housing to prevent arc-over and leakage to ground.

The higher voltage output of the HEI system required new insulation materials. To prevent ignition failure due to carbon tracking, a special material is used for the distributor cap and rotor. IT is a thermoplastic, injection-molded, glass-reinforced polyester. This material provided the dielectric and insulation properties needed and also prevented carbon tracking.

The high voltage terminals used in the distributor cap are similar in appearance to spark plug terminals. These connections provide easier attachment and better sealing of the connections. Latches are used to ensure proper connections of the plug wires to the cap and prevent any loosening or movement which might reduce the moisture of the connection. The spark plug wires are a carbon-impregnated cord conductor encased in an 8 millimeter diameter silicone jacket. Silicone wiring will withstand very high temperature and is an excellent insulator for higher voltages.

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Control modules

There are four basic types of HEI control modules: four-, five-, seven-, and eight-pin. The four-pin module was used on carbureted engines and uses conventional mechanical timing controls (vacuum and centrifugal advance mechanisms).[*citation needed*] The five-pin module was introduced in 1978 and was an early attempt at electronic timing control; it contains a provision for connecting a knock sensor.[*citation needed*] The seven- and eight-pin modules are used on early computer-controlled engines in conjunction with fixed-timing distributors, as the computer controls the ignition timing.

Pick-up Coils

The pick-up coil is not serviced separately but as an assembly with the bottom plate, pole piece and permanent magnet. This assembly, called the "pole piece and plate" in the parts book, should not be disassembled because the pole piece is centered around the axis of the distributor during production. This sets the clearance between the teeth of the pole piece and timer core.

There are seven different pole pieces and plate assemblies available. The correct part number of the pole piece and plate assembly for a particular vehicle should be determined from the appropriate parts book. The part number of a pole piece and plate assembly can be dete3rmined by visual inspection by the colored ties or connectors ant he number of teeth on the timer core and pole piece. The following is a list of pole piece and plate assemblies by pick-up coil color code.

- Blue tie or black connector body: 1876210 (V-8), 1891209 (V-6), 1880020 (L-4)
- Yellow tie or yellow connector body: 1875981 (V-8), 1880040 (L-6), 1892175 (L-4)
- Clear tie or clear connector body: 1876495 (V-8)
- Yellow connector: 1894237 V-6 (200 CID)
- Black connector: 1893894 V-6 even fire (196, 231 CID)

Ignition Coil

In the oil filled ignition coil used with conventional ignition systems, the primary winding is wrapped around the secondary winding and the secondary winding is wrapped around the iron core. The HEI coil has the secondary winding wrapped around the primary winding and the primary winding is wrapped around the iron core. The HEI coil is not oil filled; instead, the windings are covered in an epoxy compound for protection against moisture and arc-over within the coil.

Primary current is increased by reducing the length of wire used in the primary windings, thus reducing resistance.

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Inductance values[1] of the primary and secondary winding are also different in the HEI coil. Increased secondary inductance provide a higher voltage and a longer spark duration than the conventional system.

Upgrading

HEI distributors are a popular swap on older GM cars originally equipped with points and condenser type ignition systems.[*citation needed*] The HEI system produces a more powerful spark, which allows for a wider spark plug gap for surer ignition of a fuel/air mix that may not be optimal. The HEI setup has also become a popular swap into non-GM vehicles.