STRIKING THE FLAME

Caution: curves ahead

by Kip Woodring

Quite a few of us blather on extensively about advance curves in electronic ignitions. Very few of us have any idea what they really are or how they work... for or against us.

Reminds me of an old saying about "not understanding all you know." The corollary asks, "why you suspect what you cannot prove, and prove what you never suspected." Perfect clichés for what we thought we'd do with a simple test of ignition modules.

Since Harley-Davidson and Motorola are keeping their collective traps shut on just what the curve (as in advance curve) is on various factory ignition modules, we'd just find out ourselves. After all, all you need is a "dial back" timing light, patience and a steady throttle hand. You'll get the information. Wisdom, on the other hand, is a lot more elusive. For instance...

Before an engine can do anything else, it's got to start. Harder than you might think, unless you've played around with kickstarters a lot. Let's see... cold motor, rich mixture, damn little vaporization because of it... and a bunch of spark at just the right time. Any element that's out of phase here can keep you from doing much more than flooding the engine and wearing out the battery. Hence, the practical proposition of retarding the timing. Makes the whole job easier, if not possible, in the first place. Thing is, starting well and running well afterwards takes a little... dare I say... advance planning.

How much advance?

That's a lot like asking how high is up. The answer depends on so many variables, it actually varies. Not just from type to type of engine, but from engine to engine of a specific type. Just the same, number one on the list is combustion chamber shape, with compression ratio and quality of fuel taking the number two and three slots respectively. But... things like the amount of heat (or cooling, if we're talkin' alcohol) in the incoming charge, the location of "hot" spots on the way through, and how efficiently the charge is scavenged by the exhaust pipe, are major players. Oh, did I mention cam timing? Well yeah... that too. The fact is, you may have an engine running perfectly on 40 degrees of advance with 8.5:1 compression, then need to crank timing over nearer to 34 when compression is more like 10.5:1. Or... son of a gun... back to 40 to 42 when you bump up to 13:1 (or more) but then burn alcohol! And this is only full advance we've talked about!

Advance when?

It follows that some engines are a lot more sensitive to ignition timing than others. "Others" for our purpose are the ones left stock. "Some" would be the ones pushed to the high limits of power output. The more poop in our power plant the more touchy the timing. The easy part is to figure out what full advance should be. Twiddle about till the beast makes most power/least heat... wide open... and you're done. But, but, but... you do not ride wide open. So, engine speed determines a lot. Starting, you recall, takes very little advance. Running WFO on fuel takes a whole lot more. Running around town on part throttle? Well, that's why we're here.

Pop!

Pulling hard at low or medium engine speeds requires less advance than WOT (wide open throttle, natch) high speeds, because the mixture has more time to burn completely. Nonetheless, it's necessary to fire the charge, (which should burn, not explode) several degrees before top dead center in the stroke so that pressure generated maxes out a little after TDC on the power stroke. That's why it's necessary to build in an ignition curve that will run the gamut of ignition timing… ah, er, requirements. Wise folk determined a long time ago that the "gamut" amounts to 0 to 2500 or 3000 rpm. From there to redline in a normal healthy motor turbulence takes over, and the rate of combustion is automatically speeded up in unison with engine speed. In point of fact, virtually every module available for V-twin "X" engines is at full advance before 3500 rpm, if not sooner. Sooner (or later) is all we need to find out to map a module curve. All we need to get the curve to do is offer us better throttle response, no pinging, and as little latent heat build-up as possible. Getting umpteen extra ponies out the deal really isn't in the cards. You should know that, before you get anal about this information. That may be the beginning of true wisdom… at least as far as ignition modules are concerned.

Get wise to modules

1) Buells with either S1 or Thunderstorm heads are definitely combusting more efficiently and compressing more tightly than regular S2 or XL1200 heads. Therefore, they can get by with, and may benefit from, a lot less total advance than the Screamin' Eagle K-curve gives.

2) Since zero pinging and 100 percent throttle response below three grand are the objectives, it's as well to consider that in the absence/presence of those very requirements… you get more torque! Not a bunch, but a little with each pop, because the engine needn't fight itself to turn over. *N'est pas?* This may show up as "snap" at the twistgrip, much more than numbers on a dyno, but there you have it. If ignition happens too late, no harm done but energy is wasted. Too early and the piston wants to stop rotating or rotate the wrong direction, also wasting energy, but in a far more destructive fashion.

3) Any test is limited to what you can do in the "lab," so we're not about to guarantee 110 percent accuracy on these numbers. They should be within a degree, one way or the other, but you'll have to check yourself to find out. Neither can we duplicate what the ignition may do under "real world" conditions: (e.g. transition times from part throttle loadings to full throttle loadings, with intermittent traction, under loads that make the VOES kick in and out like a snakes tongue sniffin' steak) but then… the timing's not staying put under those conditions anyway. What we can say, is you'll have more to work with than you did, and with practice, all you'll need to know you can learn.

Fig. 1

Figure 1 M-Curve

RPM	Advance° (degrees of)	Advance° w/o VOES (degrees of)
1000	21	10
1250	24	10
1500	34	10
1750	34	12
2000	34	14
2500	39	15
3000	40 (full advance)	17

Stock 1200 5-speed #32433-91A 7-pin 6250 rpm (stock on '95 model Federal S2), #32433-94A 8-pin 6250rpm.

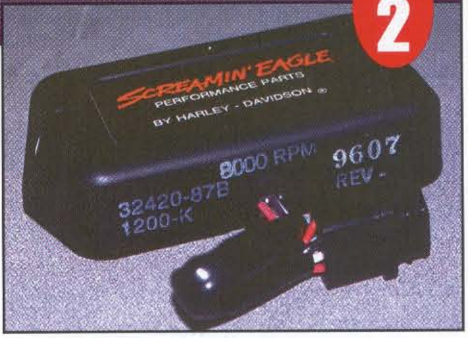


Fig. 2

Figure 2 K-Curve

RPM	Advance° (degrees of)	Advance° w/o VOES (degrees of)
1000	28	n/a
1250	28	n/a
1500	32	10
1750	35	12
2000	37	15
2500	40 (full advance)	15
3000	40	18
3500	40	18

(Screamin' Eagle) #32420-87A/B 8000 rev limit 7-pin plug, #32420-94 8000rpm limit 8-pin plug, #32597-96 6800 rpm limit 7-pin plug, #32598-96 6800 rpm limit 8-pin plug.

This module is "ye ol' standby," and works well with open chamber 1200 heads. Just the same, it's safe to say, it may not be the hot-tip unit for S1/Thunderstorm heads with their different chamber shapes and higher mechanical compression.

Figure 3 Q-Curve

RPM	Advance° (degrees of)	Advance° w/o VOES (degrees of)
1000	20	17
1250	21	17
1500	21	17
1750	23	17
2000	24	17
2500	26	19
3000	28	22
3500	32	24
4000	35 (full advance)	n/a

(Screamin' Eagle) #32633-96 6800 rpm, (Buell Race Kit) #32680-96Y 6800 rpm (same) 8-pin plug, #32465-95A 6250 rpm 8-pin plug (stock on '95 California model S2)

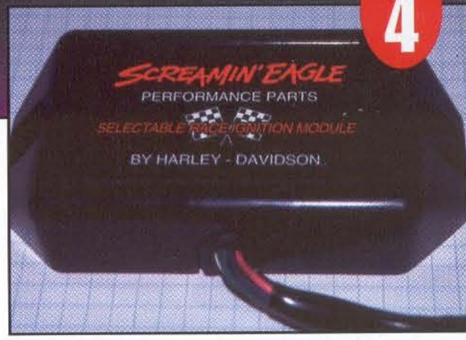
Fig. 3

Here's the one they say is the hot item for Buells (except S2s with stock heads), but it may also be the stock item, offering merely a higher rev limit. This is a game the factory has resorted to more and more as they fine-tune advance curves. Find one that works... then offer it with various rev limits... only! Late model Harley Big Twins and Sportsters are treated this way... why not Buells? If it works...

Figures 4 & 5 #32654-98 "Selectable curve"

RPM	C-1	C-2	C-3	C-4
1000	24	25	27	25
1250	27	27	27	29
1500	37	35	34	31
1750	38	37	35	34
2000	38	38	35	35
2500	38	38	35	35
3000	(full advance)		38	38

Fig. 4



Secretly suspicious that this item might be a marketing gimmick, I learned better. Still, I have some reservations...

The module has a "retard" switch position. Presumably for folks stuck in Mexico or somewhere where the fuel, in terms of grade and/or quality, is actually worse than California's. Any other use tends to escape logic, but you can't flip the switch(es) without removing the module! What's more... when put in that mode:

1000 rpm = 23
1250 rpm = 24
1500 rpm = 29
1750 rpm = 29, and stays there, on curve one.

On any/all curves it hits 29 degrees by 1500 rpm, and stays there! Just for fun, we tried unplugging the VOES, then reshooting the timing at 2000 rpm. On curve one, that worked out like this: "Normal" = 31, "Retard" = 37! Meaning, it seems, that with the VOES plugged in and the module on curve one "normal," you get the

Fig. 5

same part throttle timing as you would if you set it on "retard" and unplugged the VOES? Figure that one out... I dare ya!

Figure 6 The Great Unknown(s)

1998 and later Sportsters have done away with separate modules entirely! Current wisdom says they can do it all with the little fella that lives in the cone. Screamin' Eagle versions... ditto. With two rev limits, 6800 and 7500, where do you want to go today? You could most likely make this piece (or its aftermarket equivalent, like Crane's HI-4, or Compu-Fire, or...?) work on your Buell, with some significant rewiring. It sure would "clean up" the bike a bit, but is it worth the effort to save the 10 ounces?

Figure 7

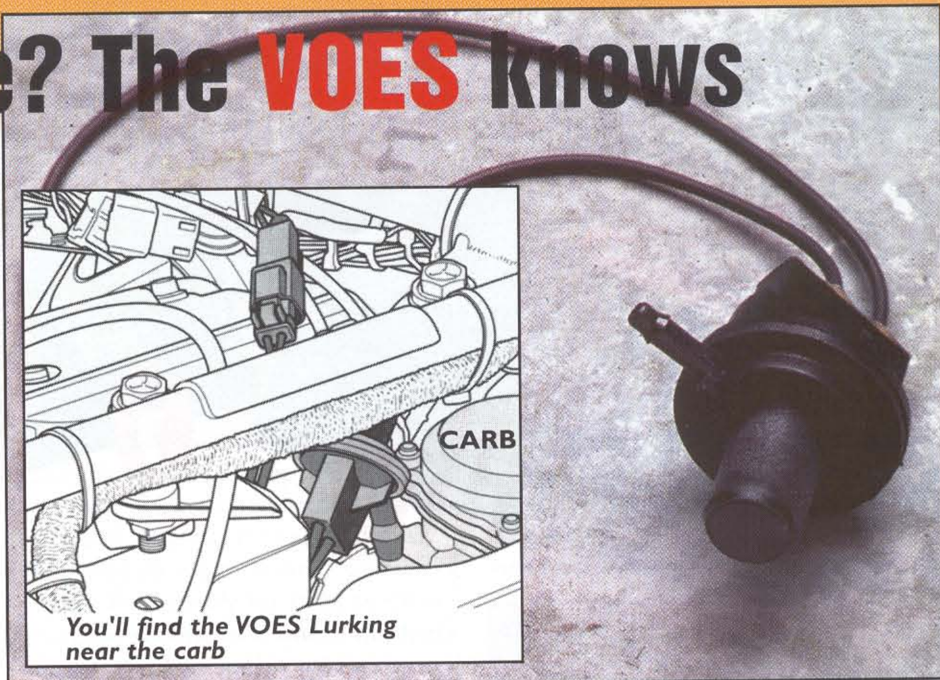
Especially... if this kind of thing appeals. Adjustable and them some! The HI-4E is a sophisticated apparatus, if ever there was one, and you need to be "wiser" than it is before you go messing about too much. Still, with the ability to time each cylinder separately, a "race mode" option, "set your own" rev limit, and a host of variables, it's a tantalizing doodad. However...

Last thing. We didn't test any aftermarket ignition modules! Not because we have anything against 'em, but we just didn't have any handy. (The HI-4E already had an owner/operator.) Hey, we didn't even test each and every factory module that might work on a Buell. All the same, the four you do see "mapped" represent the standard by which others must be judged. And the only one that "got away," is the ever popular "J" curve, standard issue on 4-speed models. Couldn't get our hands on one in time. We reserve the right to test that one, and any/all others we've been curious about, in a future issue, though.

Once you have a curve that works, the next thing to investigate is a concept called multiple spark discharge, not to be confused with single-fire, although it can be used in conjunction. When we get that info, we'll be happy to put you wise to it. So, till that issue... in advance! ▲

Which curve? The VOES knows

Almost all Harley/Buell ignition modules offer two advance curves, one light load/high vacuum range, and one heavy load/low vacuum range. The gizmo that determines which range to use for what is the Vacuum Operated Electrical Switch… affectionately known as the VOES. The VOES interprets engine load via vacuum in the intake tract. The VOES is open when the throttle's barely cracked open and intake vacuum is pretty high. Nail the throttle wide open, and vacuum drops like a rock! The VOES shuts off under those conditions, which retards the timing, or more correctly, switches the module to the second ("heavy load") advance curve.



You'll find the VOES Lurking near the carb

The adjuster screw (arrow) is under the end bit of the switch that's lookin' right at you in this shot. Attach a Mity-Vac (or the equivalent) vacuum gauge, and an ohmmeter to the VOES. Increase the vacuum until the ohmmeter reads zero… record the reading on the vacuum gauge… and deal with it from there. Most times no dealing is required, just so ya know.

There are a few nuggets of wisdom to be gained from this information…

First, disconnecting the thing is not a good plan! Without it you generally get a pinging monster that runs too hot.

Second, efficient heads, like the S1/Thunderstorm types, don't require as much "retarding" in the secondary curve anyway. Mapping the two curves in the "Q" module, for example reveals a difference of only 4 to 6 degrees from idle to 2000 rpm, and never more than 7 degrees at any rpm. The older Screamin' Eagle "K" module, on the other hand, generates more like 12 degrees difference. And the worst of the bunch, the "M" curve, a massive 24 degrees at 1500! No wonder stock 1200 Sportsters, with open-chambered heads and "smog-friendly" advance curve… ping like crazy!

Third, as a rule, the bigger the gap in degrees between the two curves at any given rpm, the more sluggish the bike feels when you roll on. If the motor is fed an ignition lead far different from the one it was just using (like the "M" curve does), it takes more time to wind up. In essence, this is what throttle response boils down to.

Fourth, you can adjust the VOES. There's a waxy-looking rubber plug in the end of the thing, you can remove, exposing an adjustment screw. Turning the screw in about 1½ turns, increases the vacuum required to close the switch to approximately 5½ inches. Up from the standard 3½ to 4½, as checked with a vacuum pump and ohmmeter. You can reduce vacuum by going the other way with the screw as well, but won't ever need to. The rule of thumb with vacuum settings is: "if it pings, lower it; if it lags, raise it." ▲

—K.W.

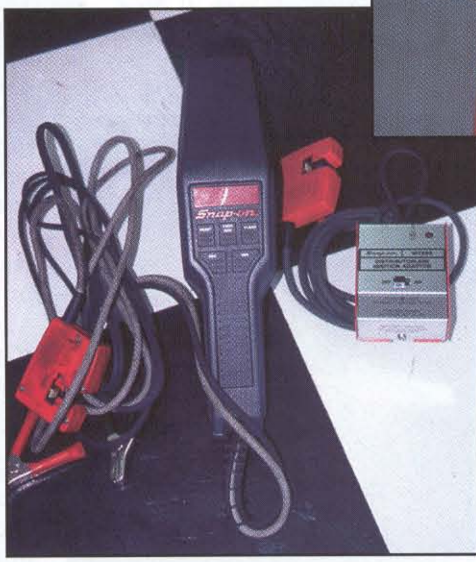
Shed some light

Exactly how do you "map" an advance curve? Well, we doubt it can be done "exactly" without specialized equipment (an oscilloscope, impedance tester, who knows?), and our method is certainly crude, yet better than not knowing or being able to figure it out at all! You need to understand that the data collected can be less than 100 percent accurate too. So, if you do map your module's curve, be prepared to do it two or three times to make sure you get the same answers over and over. Once you do you'll have a rough idea of what goes on with electronic ignition curves. But… to get even a rough idea…

1) You'll need a suitable quality "dial back" timing light. We used a Matco, but Sun and Snap-on sell them as well.

2) You'll need a reasonably decent timing plug, or a plastic raincoat! It gets damn messy with all that oil spraying over you. None of the readily available plastic plugs is all that great, frankly, but unless you want to try making one out of PVC, there's not much choice. The PVC should have threads tapped onto it so you can screw it lightly into the

A Matco MD84 digital dial-back timing light was the weapon of choice for this particular battle. With its digital readout and built-in tach function, it gets you where you want to go pretty painlessly and accurately.



Snap-on is always a player when it comes to trick tools, albeit expensive ones. This light is considerably more expensive and requires an adapter (the red box on the right) to work properly on H-Ds. That said, if you want to do this kind of thing at home… you must have good toys…ah, tools… to do it right.

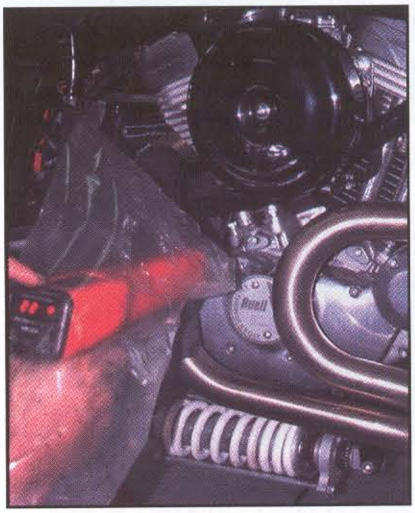
timing hole, and be about three inches long. You may even want to super glue some kind of clear lens on the end, say an old flashlight lens. Once in place, nearly touching the flywheels, hook up the timing light and...

3) find a means to hold the throttle absolutely steady. On S2 Thunderbolts, you can install a Harley throttle lock (#56397-74C), other models can be jury-rigged with pliers and a heavy rubberband. Pliers jaws go around the throttle grip, handles over the brake lever, and rubberband around the handles, tight enough to hold the throttle in position.

4) The timing light has a tach function and you should go by that reading, not the one on the motorcycle. Set engine speed and shoot as per timing light instructions. Shoot to the TDC line on the flywheel, not the double dot, when mapping a curve! What you're doing here is comparing curves... not shooting timing. Setting ignition timing is a process that differs from year to year. That you do by the book for the model/year you own. This is a different process (although it's a good idea to ensure the timing is spot on before you worry about anything else). Write down the results, and that's all there is to it! ▲

—K.W.

Another reason timing is a messy operation on "X" motors is the fact that, unlike Big Twins, the flywheels don't cover the hole! Oil flung about by their rotation has very little reason to stay out of your face under those circumstances! Yeah!, messy job, but somebody... well, you know the rest.



It's in the bag! Which may be the best way to protect the tool and yourself. Since the store-bought types leave a bit to be desired, building your own timing plug to prevent the "amber shower" may be the most workable option. Otherwise, do it this way, but be quick about it!