Determining Injector Opening-Time for Sharktuner

Introduction:

One of the biggest questions when tuning with new injectors is what is opening-time to use for Sharktuner. There are a lot of “knobs” to adjust in Sharktuner, and most of them are interrelated. Injector opening-time is one of those variables that effects everything (except cranking). Injector opening-time (aka dead time, latency, offset, etc) varies greatly with the various injectors that are available, and if not correct then the actual fuel that is injected will differ from what the LH calculated.

Since everything is interrelated, it is easy to tune around an incorrect opening-time value. For example if the actual injector opening time is 1.19 ms (e.g. Ford M9593-BB302) and you leave Shartuner set to the default 0.94 ms, then the injectors will open later than the LH expects and less fuel gets injected than LH calculated. If the fuel map is changed accordingly then that compensates for the mis-calculation, to a point.

The first point where an opening-time error runs into problems is running out of adjustment range with the fuel map, hitting the max value (±127) and needing more adjustment. Less obvious are problems with the various secondary corrections: warmup map, voltage correction, etc. Those calculations all get done on the "net" pulse width, before opening-time is added. So if your opening-time setting is incorrect, and you adjust the map accordingly, then there will be tuning problems later.

You can save a lot of headaches by first getting the opening-time correct, then doing the basic fuel-map tuning, and then doing any needed tweaks to the warm-up map, etc.

How to find the correct opening time?

Ford Motorsports is pretty good about publishing their specs, and it is possible to calculate correct opening-time for our operating conditions. For the popular (but no longer in production) M9593-A302 24# injectors, the correct opening time is 0.84 ms, and for the BB302 30# injectors, use 1.19 ms. We've verified both of those numbers and the specs are correct.

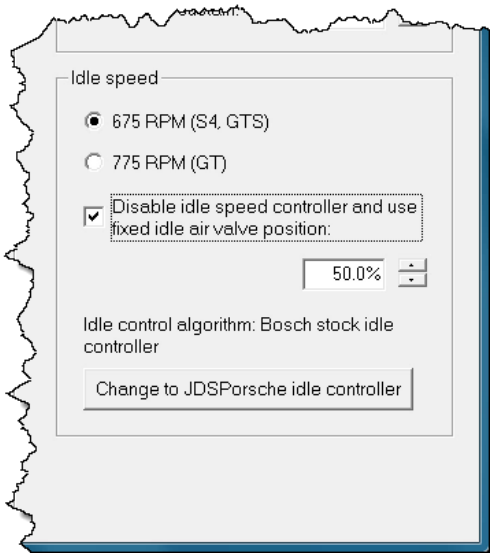
Bosch doesn't publish specs for their other injectors. Some other companies do, but the numbers generally haven't made sense.

Some recent work on Sharktuner diagnostics tools has resulted in an injector test mode that can be used to determine the correct opening time. It is still experimental but it has given good results so far.

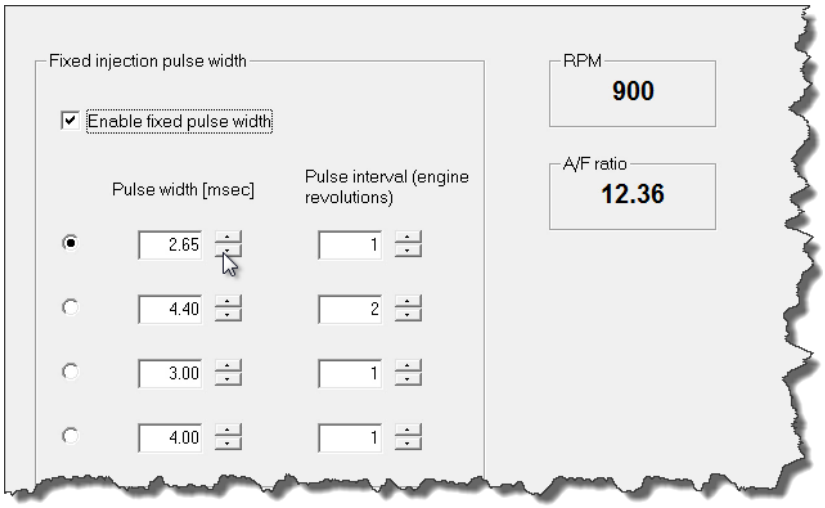
Sharktuner Method:

In a nutshell, the method is to compare one fixed injector pulse per engine revolution to a pulse per two revolutions. If the net amount of fuel being delivered is the same, then the mixture will be the same and the AFR won’t change. If the opening-time were zero, then the width of one pulse per two revolutions would simple be double that for one pulse per revolution. But the opening-time is a significant portion of the pulse-width, and we can calculate it by comparing those two pulse-widths.

First create a static "test engine": With the engine warmed up and stable, we need to disable the ISV control (for a constant air flow) and then set up fixed injector pulse-widths. Do this as follows:

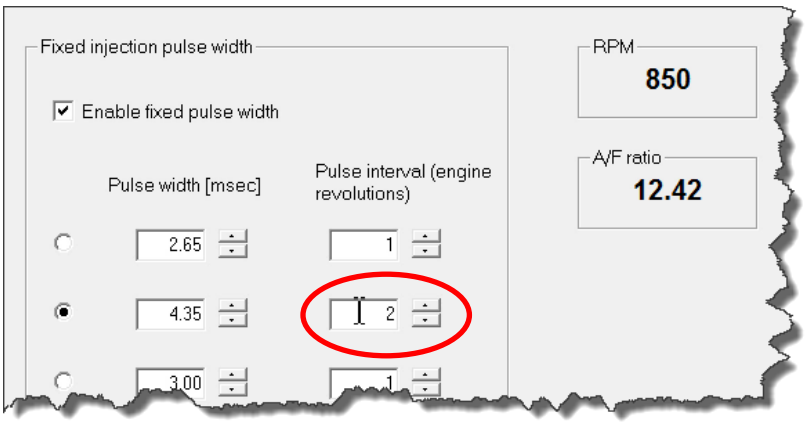


1. First select ST's Fuel-Monitor page, and note the ISV% setting. This should be in the range of 50-55%.
2. Now select the Fuel Parameters page, set the ISV% in the lower-right to 5-10% above the value noted above, and select "Disable idle speed controller…". Adjust the ISV value as needed for a fast idle speed of around 1200 rpm.
3. Next, go back to Fuel Monitor page and note the injector pulse width. This is the total injector time (opening time plus actual fuel) that is needed to run the engine in the current state, and should be in the 2.1 to 2.5 ms range.
4. Now select the "Fuel Test" page (enabled under Tools menu). This a special test page for the fuel injectors. In the first "Pulse width" box select a pulse width that is 0.1 or 0.2 ms higher than the pulse-width noted above. This example was approx. 2.51 on the Fuel Monitor page, so we entered 2.65 ms, we want the mixture a bit rich for best engine stability, in the 12.0 to 12.5 range.



5. Now check "Enable fixed pulse width". The engine should hiccup slightly and keep running, but now with a fixed injection pulse. Adjust the pulse as needed for an average AFR of 12 to 12.5.
6. Do not touch the throttle, this will stall the engine because the fuel cannot respond. If the engine stalls, UN-check "Enable fixed pulse" and restart, then try again after setting a higher ISV setting or a different fixed pulse width.
7. Once RPM and fuel are stable, then set the parameters for the second row of pulse width boxes: Set the second pulse-width box to twice the value of the first minus a "best-guess" for opening time (1.00 ms is a good guess), and then set the second Pulse Interval box to "2" (one pulse per two revolutions). For our first try above, we guessed 0.90 msec opening time, and our first pulse was 2.65 ms, so we set the second pulse to 5.30 minus 0.90, or 4.40 msec, and one pulse per two revolutions.

8. Now click the dot for the second Pulse-width entry. The engine will hiccup but should continue running with the same RPM, same AFR. If the AFR increases (leaner mixture) then increase the second pulse-width; if AFR decreases (richer) then decrease the second pulse width. Click between the first and second pulse-width selection, changing the pulse-width as needed until the AFR is about the same for both selections, as close as possible—AFR's bounce around a bit so just try to match the average values. .



9. Note the first and second pulse widths. Double the first and then subtract the second, and that is the opening time. In this example (a real test with a stock '88 S4) we wound up with 2.65 and 4.35 msec after adjusting. So the result was 2.65 * 2 = 5.30, minus 4.35, is 0.95 msec. (The factory number for these 19# injectors is 0.94 msec). This result is the opening-time value that is needed for Sharktuner. Be sure to make a note of this.

10. Now UN-check the "Enable fixed pulse" box on the Fuel-Test page, and UN-check "Disable idle control" on the Fuel Parameter page. This restores normal engine operation.

11. Enter the opening-time value calculated above into Sharktuner's Opening-time box on the Fuel Parameter page.

Note that changing ST's opening-time parameter will affect the fuel map, so retuning will be needed.

How it works: We adjust the pulse-width T2 in the second (2 revolution) case to be the same AFR as the first pulse T1. So we know the net fuel injected in two revolutions is the same, and the only difference is two opening-times versus one.

By definition: T1 = Topen+Tinj and T2 = Topen+2*Tinj

Solving each for Tinj and then equating, we get: T1-Topen = (T2-Topen)/2

And solving that for Topen, we get: Topen = 2*T1 – T2