Harley-Davidson Electronic Fuel-Injection Tuning Aids

Don't Get Caught in the Dark-Know Your Options

http://www.hotbikeweb.com/tech/0704_hbkp_harley_davidson_electronic_fuel_injection_tuning/index.html

Harley-Davidson introduced electronic fuel injection (EFI) to its product line in 1995. Since then, the factory has followed a slow but steady evolution toward equipping more and more models with EFI. Starting in 2007, all Harley models are shipped with EFI, including Sportys for the first time. The impetus for migration to EFI is to meet the more demanding federal emissions standards intended to take effect in California in 2006 and in 2008 for the other 49 states. EFI reduces fuel emissions because it meters fuel more accurately than a carburetor. It also offers street riders the benefits of improved cold or hot starting, crisper acceleration under varied operating conditions, and smoother running at high altitudes.

Nonetheless, as with most things in life, there is no free lunch. EFI is more complex than carburetion and often requires increased costs for a serious performance induction package (parts and tuning). In fact, many engine builders are constantly searching for the Holy Grail-the perfect EFI "map" for their performance engine combination. For these reasons, some performance manufacturers offer custom EFI maps for specific performance parts combinations. However, if you deviate slightly from the exact parts combination or the planets align unfavorably, EFI tuning can get dicey. For those reasons, it is helpful to know a few basics about electronic fuel injection and some of the tuning aids available.

To better understand electronic fuel injection, it helps to understand some carburetor basics. With a carbureted engine, you have a main fuel tank and a carburetor mounted to an intake manifold, which in turn is mounted to the cylinder heads. The carburetor includes a venturi, fuel and air jets, and a butterfly. Airflow is regulated through the induction tract by the carburetor butterfly. As air flows through the venturi, it creates a low-pressure area at the venturi. At the same time, fuel is gravity-fed from the motorcycle's main fuel tank to the carb's float bowl, or fuel storage area.

Fuel jets then meter approximately the correct amount of fuel based on the vacuum signal at the venturi. The number of tuning jets used varies depending on the carb design, but simple carbs generally include three jets or circuits (idle jet, low-speed jet, and high-speed or main jet), while complex carbs have more.

To tune a carb, one simply replaces a jet with a larger (richer) or smaller (leaner) jet, turns a screw either in or out, substitutes a tapered needle with another, or drills or plugs various fuel or air orifices. As such, carburetor tuning is straightforward and uses tangible items such as jets, screws, and needles for tuning. Additionally, simple tools such as the common screwdriver are typically used for adjustments.

Conversely, EFI is rather hypothetical and shadowy because it uses complex computers, obscure "black boxes," and mysterious injectors to control an engine's fuel supply. In comparison to a carbureted engine, an electronic fuel-injection system mounts a throttle body instead of a carburetor to the intake manifold. The throttle body, also known as a TB, looks similar to a carburetor and includes a butterfly to regulate airflow, but it has no jets or float bowl to store fuel.

A TB's main function is to regulate air. Two electronically controlled fuel injectors (one for each cylinder) are mounted into the intake manifold and control the fuel supply. An electronic control module is mounted either under the motorcycle's seat or under the cover located on one side and just below the seat. The map-based ECM receives information from several engine sensors and, based on its map, sends instructions to the fuel injectors as to when to start and how long to spray (pulse width) fuel into the intake tract, while the TB butterfly regulates the air supply.

Instead of using tangible jets and simple screwdrivers for tuning, EFI requires complex computers for creating baffling fuel maps, which control the amount and the timing of the fuel supply by the injectors. As a tuning option, a simplified add-on "black box" is sometimes connected inline between the ECU and fuel injectors. The add-on black box intercepts the stock ECU signals to the fuel injectors and replaces the signals with modified instructions for the correct fuel delivery.

Now that you have a brief understanding of EFI, let's take a look at some of the EFI tuning aids available to the engine builder and tuner to help eliminate the dreaded popping, stumbling, surging, pinging, flat spots, and overheating sometimes encountered with modified EFI engines.

Tuning aids for Harley-Davidson's EFI systems can be divided into three major categories:

- Downloadable maps (called ECM calibration by Harley)
- Add-on modules
- Map-based reprogrammers (an add-on module may or may not be used)

Downloadable Maps

Harley-Davidson and several aftermarket performance parts manufacturers offer downloadable maps designed for a specific engine parts combination. Harley calls its downloads "ECM calibration" and has several different calibrations for various Screamin' Eagle Stage I and Stage II performance kits. Harley's ECM recalibrations are specifically designed for engines equipped with Harley-supplied EFI systems (Delphi or Magneti-Marelli). Basically, you buy the recalibrated fuel map from a Harley dealer and then pay a small labor charge to have it downloaded into your ECM. Additionally, some makers of aftermarket EFI performance parts offer downloadable fuel maps from their websites for specific engine combinations.

A generic ECM recalibration or downloadable map is the lowest-cost method for taking the guesswork out of tuning an EFI-equipped engine with performance modifications. What you have to keep in mind, however, is that your engine combination must match the performance modifications addressed by the downloadable map, and even then there are exceptions. If you cannot locate a map that tunes your engine properly, you must consider using either an add-on device or a map-based reprogrammer to get the proper tuning.

Add-On Modules

An add-on module is a unit that is used in combination with the engine's stock ECM. Most add-on modules are potentiometer-based devices that do not require a computer for adjustment. Some include one or more base maps for certain engine/exhaust system modifications. One unit, the Power Commander by Dynojet, is a programmable map-based device.

An add-on module connects in series between the stock ECM and fuel injectors and modifies the ECM's output signals before the signals reach the injectors. These units are adjusted by using a screwdriver to adjust the potentiometers, or "pots," which adjust rpm transition points (not the ability to increase the rev limit) and air/fuel mixture.

Potentiometer-type devices are generally load-based devices in that they add more fuel at wide-open throttle than at low-throttle settings. Some add-on modules can only instruct the injectors to add fuel or richen the air/fuel mixture, while others can direct the injectors to both add (richen) and remove (lean) fuel.

The ability to lean the air/fuel mixture within certain rpm ranges can be important for successful tuning. Pot-based devices are relatively low-cost but have certain limitations as to the range of performance engine modifications they can tune.

Depending on the brand of module, add-on devices include up to four pots, which allow setting between one and three rpm ranges for air/fuel mixture. Basically, you set the transition points for the rpm ranges and then adjust the air/fuel ratio within those ranges. Potentiometer-based devices include the Cobra FI2000, Dynatek F.I. Controller, Harley-Davidson SE Pro EFI Race Fueler, Kryakyn Wild Things FI Controller, Rev Tech Digital Fuel Optimizer (DFO), and the Total Fuel Systems EFI Control Module. Several pot-style devices are currently undergoing design updates to digital where the pot adjusters are reduced to three buttons, a mode select, and plus and minus capability.

The Vance & Hines Fuelpak is another add-on device that connects in series between the ECU and injectors. Instead of using a screwdriver for adjustment, you enter numbers into 18 different "modes" using the display and buttons on the device. Vance & Hines includes a set of numbers for your model and year of Harley, exhaust system, and any ECM updates that you enter into the Fuelpak using the buttons and display. The Vance & Hines Fuelpak includes the ability to either add or reduce the amount of fuel.

The Dynojet Power Commander is another add-on device that connects in series between the ECM and fuel injectors, but it differs from basic pot-based add-ons because it is a map-based module that allows for the reprogramming of fuel maps. Therefore, it will be covered below under map-based reprogrammers.

Map-Based Reprogrammers

Once your engine gets into the 100-plus cubic-inch range, has big cams installed, or has heavy cylinder-head porting, pot-like devices cannot segment the rpm ranges into small enough portions to satisfy the engine's air/fuel requirements. That is where map-based devices shine. The most capable and generally the most costly EFI tuning aids are map-based modules. Map-based tuning aids contain one or more look-up tables called maps for controlling fuel, ignition timing, rpm, start-up, and warm-up functions, just to name a few. The tables are finely divided into many small cells for close tuning over a wide range. Each cell represents a number indicating the percentage of fuel change, either plus or minus from a base value, based on various engine data, such as rpm, throttle position, and so on. We'll cover two map-based reprogrammers: the Dynojet Power Commander (hardware- and software-based device) and the Harley-Davidson SE Race Tuner (software-based).

Dynojet's Power Commander is an add-on computer that connects in series between the ECM and fuel injectors. The add-on computer stores maps that can be reprogrammed with a personal computer (PC) for a wide range of modified engine combinations. Separate fuel and ignition tables are available for both front and rear cylinders, and the newest models allow the engine's rev limit to be raised above the stock value. Three buttons are provided on the computer, allowing for manual richer or leaner adjustments in 2,000-rpm-wide bands. Power Commanders include a CD-ROM with current maps for many engine combinations, and new maps can be downloaded from the company's website.

The Harley-Davidson Screamin' Eagle Race Tuner is a software map-based reprogrammer that does not require an add-on module because it has the ability to reprogram the stock ECM. The Race Tuner software program comes on a CD-ROM along with a hardware "key" (adapter) that allows connecting a PC to the stock ECM. Once the Race Tuner uploads a new map into the stock ECM, the PC and hardware key are removed, and no additional parts remain on the bike.

In addition to allowing fuel, ignition, start-up, warm-up, and rev-limit modifications, the Race Tuner also includes a function for setting injector size, which allows for greater tuning flexibility. Several operating modes are available, including basic, advanced, and data monitoring. The Race Tuner and Power Commander are similar in that table cells represent the percentage of change, either plus or minus. One thing that is different, however, is that the Race Tuner will not allow you to download a map from it as the Power Commander will.

EFI Fuel Map

An EFI map is a multi-dimensional look-up table that's stored (downloaded) into the fuel injection's computer (called the Electronic Control Module, or ECM, by Harley-Davidson). A map is created for a specific engine parts combination and is used by the ECM to adjust the fuel delivery of the fuel injectors based on throttle position, rpm, and other critical factors. In addition to the fuel curve, maps can also control ignition timing, rev limit, start-up, and warm-up functions. For stock Harleys, the map is preprogrammed and loaded into the ECM at the factory.

By using a PC, the ECM and some add-on modules can be reprogrammed with a custom map designed for a modified engine combination. A custom map increases or decreases fuel delivery from the stock map settings to meet the needs of a custom performance engine. Custom maps for specific parts combinations are available from various manufacturers, and they can be created ad hoc in the field through dyno or road testing.

Conclusions

If you are modifying a Harley EFI (Delphi or Magneti-Marelli) engine with more than a high-flowing air cleaner, chances are you will need to adjust the engine's fuel curve to achieve maximum power and smooth ridability. Although nothing is set in concrete, here are a few things to consider when modifying an engine with a Harley-based EFI system

Harley-Davidson offers a wide selection of ECM recalibration "downloadable maps" for its SE Stage I and Stage II kits that often get the job done. Fuel-curve adjustments for minor performance upgrades-high-flowing air cleaners, free-flowing exhaust systems, and some mild cams-can often be handled by low-cost pot-style devices.

Once you install moderate to big cams (and sometimes even mild cams) or venture into the realm of 100-plus cubic-inch displacement, you're probably going to need a map-based device offering a wide range of fuel curve adjustments, such as a Dynojet Power Commander or Harley-Davidson Race Tuner

Sometimes you can download a map to get the tuning close, then do final tuning with an add-on or map-based device. Moreover, if you are going to make modifications in small increments over a long period, it is usually more cost-effective to start with a map-based SE Race Tuner or Power Commander, because that's what you'll need in the end to get the tuning correct. Before making a decision on purchasing a tuning device, make sure you really need one.

Some mild engine combinations don't need anything beyond the stock ECM. Finally, make sure downloadable maps are available for your engine combination and that you have a local tuner who's knowledgeable about the device you are considering. A knowledgeable and honest tuner is the best friend you can have when delving into the complex world of EFI. Happy tuning!