The electronic fuel injection system engineering essay

\n[toc title="Table of Contents"]\n

\n \t

\n[/toc]\n \n

The Electronic Fuel Injection system can be divided into three: basic sub - systems. These are the fuel delivery system, air induction system, and the electronic control system.

The fuel delivery system consists of the fuel tank, fuel pump, fuel filter, fuel delivery pipe (fuel rail), fuel injector, fuel pressure regulator, and fuel return pipe.

Fuel is delivered from the tank to the injector by means of an electric fuel pump. The pump is typically located in or near the fuel tank. Contaminants are filtered out by a high capacity in line fuel filter.

Fuel is maintained at a constant pressure by means of a fuel pressure regulator. Any fuel which is not delivered to the intake manifold by the injector is returned to the tank through a fuel return pipe.

The Air Induction System

The air induction system consists of the air cleaner, air flow meter, throttle valve, air intake chamber, intake manifold runner, and intake valve.

When the throttle valve is opened, air flows through the air cleaner, through the air flow meter (on L type systems), past the throttle valve, and through a well tuned intake manifold runner to the intake valve.

Air delivered to the engine is a function of driver demand. As the throttle valve is opened further, more air is allowed to enter the engine cylinders.

Mostly the L type EFI system measures air flow directly by using an air flow meter. The D type EFI system measures air flow indirectly by monitoring the pressure in the intake manifold.

Electronic Control System

The electronic control system consists of various engine sensors, Electronic Control Unit (ECU), fuel injector assemblies, and related wiring.

The ECU determines precisely how much fuel needs to be delivered by the injector by monitoring the engine sensors.

The ECU turns the injectors on for a precise amount of time, referred to as injection pulse width or injection duration, to deliver the proper air/fuel ratio to the engine.

Basic System Operation

Air enters the engine through the air induction system where it is measured by the air flow meter. As the air flows into the cylinder, fuel is mixed into the air by the fuel injector.

Fuel injectors are arranged in the intake manifold behind each intake valve. The injectors are electrical solenoids which are operated by the ECU.

The ECU pulses the injector by switching the injector ground circuit on and off.

When the injector is turned on, it opens, spraying atomized fuel at the back side of the intake valve.

As fuel is sprayed into the intake airstream, it mixes with the incoming air and vaporizes due to the low pressures in the intake manifold. The ECU signals the injector to deliver just enough fuel to achieve an ideal air/fuel ratio of 14. 7: 1, often referred to as stoichiometry.

The precise amount of fuel delivered to the engine is a function of ECU control.

The ECU determines the basic injection quantity based upon measured intake air volume and engine rpm.

Depending on engine operating conditions, injection quantity will vary. The ECU monitors variables such as coolant temperature, engine speed, throttle angle, and exhaust oxygen content and makes injection corrections which determine final injection quantity.

WHAT ONE HAS TO DO TO CONVERT CARB TO EFI IN CASE OF A CAR

Here's what is required for complete conversion

EFI head and intake manifold with everything still attached.

Crossover tube, MAF sensor and air box

Fuel tank with fuel pump

Entire wiring harness from the car.

EFI computer

EFI distributor

EFI coil/igniter

EFI gauge set in the dash

Knock sensor, main relay

Anything else that was attached to the wiring harness

Other things which are also essential

LC Engineering EFI Pro cam

Fel Pro head gasket set

Fluids

These are the steps

Out with the old…

Air cleaner off

valve cover off

Head off

Head on the bench with the intake removed.

EFI intake and EFI head

Carb head and EFI components installed

Certain small things that we found were different were:

There was some sort of smog device bolted to where the EFI fuel filter goes. It isnt used with EFI and was discarded as were the air tubes that go above the header.

The high pressure fuel line has to be either made or salvaged.

The vacuum hose for the brake booster is different between carb and EFI.

The upper radiator hose is different between carb and EFI

The good thing is that two of the plugs that go into the computer can be disconnected and are only go to the engine. So, if you unplug these from the intake, then pull the intake intact. The third plug has the power and other things going to it for the EFI.

All game is to take your time and check each wire coming out of the computer.

There seems to be only 3 components outside of the “ normal” EFI stuff.

The main EFI relay located in the interior fuse panel under the driver’s side dash. The circuit opening relay located under the passenger side dash. This is controlled by the MAF sensor and turns on and off the fuel pump. It is also tied into the main EFI relay.

The solenoid resistor is connected to a switched power source (IGN) and goes to the fuel injectors. This is located in the engine compartment passneger side.

Pretty much, the only thing that is not straight forward is how these three components are wired.

Mathematical Formulation;

Top of Form

Most EFI systems have a standard set of sensors. These include:

The Barometric Pressure (BARO) Sensor, which provides the ECU with the atmospheric air pressure reading.

The Engine Coolant Temperature (ECT) Sensor, which provides the ECU with the engine’s current operating temperature. This is important because fuel vaporization varies for different engine temperatures. A cold engine requires more fuel while a hot engine requires less.

The Intake Air Temperature (IAT) Sensor, which the ECU needs to take into account when determining pulse duration.

The Mass Air Flow (MAF) Sensor, which is a tube positioned after the air filter in the air intake duct. The MAF sensor has a fine platinum wire that spans across the tube. The wire is heated by electrical current to maintain a constant temperature above ambient. The air flow past the wire cools the wire and more current is required to maintain the constant temperature. Thus, the amount of current required to maintain the constant temperature indicates the air flow rate. The air flow rate is divided by RPM to determine the pulse duration.

The Manifold Absolute Pressure (MAP) Sensor, which uses manifold vacuum to measure engine load. An EFI system that uses a MAP sensor does not require a MAF sensor as it can use the input from the MAP sensor to determine the required pulse duration.

The Oxygen Sensor (O2S), which is used to measure the amount of oxygen that is not consumed during combustion. This is important for the correct operation of the catalyst converter and is used for emissions control rather than performance or economy. The O2S is located in the exhaust system and is an after-the-fact measure of the air/fuel ratio. Too much unburnt fuel in the exhaust indicates a lean mixture while too little oxygen indicates a rich mixture.

The Crankshaft Position (CKP) Sensor, which is important for timing purposes as it tells the ECU which spark plug to fire and which injector to open at any given point in the Otto cycle.

The Throttle Position (TP) Sensor, which is another important sensor as the throttle position and the rate of change in the throttle position indicates the what the diver wants the car to do.

Top of Form

The modifications we can perform on an OEM EFI are somewhat limited because the OEM ECU is not reprogrammable. However, there are a number of things we learned that we mechanical engineers do to modify the EFI system without having to reprogram the ECU. We can increase the fuel pressure as this is one reading that the ECU of a normal efi kit used in the cultus eg does not take into account – it assumes the fuel pressure is a constant 30 psi(an estimated value given by Pak Suzuki) above intake manifold pressure; we can intercept the pulse signal form the ECU, alter it using input from the manifold pressure and send it to the injector; we can increase the injector nozzle size; or increase the number of injectors. However, your best option, performance wise, is to install an aftermarket ECU. In the next few pages we'll discuss each of these options.

Bottom of Form

Bottom of Form

Top of Form

There are a few important factors that our study shows that must be taken into account when installing an efi engine. These are: the pulse duration of the injectors and the duty cycle.

The injector pulse duration is the amount of time that the injector is held open so that it can inject fuel into the combustion chamber. The pulse duration is controlled by the engine control unit (ECU) and is dependent on various sensors in the electronic fuel injection (EFI) system. The longer the pulse duration, the more fuel is added to the air/fuel mixture. The amount of fuel required at any one time varies by the amount of air flow, the air density, the engine load, and the engine temperature. Therefore the pulse duration will vary. However, there is only a limited amount of time that the injector can be held open at each revolution of the engine. This amount of time is reduced as engine speed increases. For example, at 600 RPM the available time is 0. 1 seconds (60 seconds in a minute divided by 600 revolutions) but at 6, 000 RPM it is only 0. 01 seconds. The pulse duration relative to the available time at the engine red line is called the duty cycle and is expressed as a percentage. Thus a duty cycle of 80% means that at the engine red line the pulse duration (the amount of time the injector is help open) is 80% of the available time.

Top of Form

INCREASING THE DUTY CYCLE

Top of Form

INCREASING INJECTOR NOZZLE SIZE

Top of Form

Performance ECU Chips

Top of Form

Replacing the stock ECU chip with a reprogrammed performance chip is a good option for anything up to a 10% increase in engine power. This is mainly due to the way in which the stock ECU chip is programmed. In essence, the stock ECU is programmed for optimal performance at peak torque so as this ensures that the car is drivable at low engine speeds. As most cars would be driven at low engine speeds of up to 3, 500 RPM, ensuring that the car drives perfectly at these engine speeds is perfectly reasonable; unless you want to modify your car! A reprogrammed performance chip will be programmed for optimal performance up to the engine red line, releasing a moderate power increase but making the car less drivable at lower engine speeds.

Top of Form

THE FUEL PICKUP

The fuel pickup should also get some consideration, especially on a modified street race car with a steel fuel tank. On such vehicles the fuel level in the fuel tank can drop below the fuel pickup during hard cornering or heavy acceleration and heavy braking and can cause a momentary drop in fuel pressure and engine performance. The solution is to have a secondary fuel pump supply a small fuel reservoir or swirl pot that feels the primary fuel pumps. The fuel reservoir is a simple cylinder with an fuel inlet from the secondary pump at the side, a fuel return line at the top and fuel pickup lines to the primary pumps at the bottom. The fuel reservoir should have a capacity of at least 1 liter and should be mounted low, beside the fuel tank. With a fuel reservoir, the primary fuel pumps will always have a fuel supply even under hard cornering of heavy acceleration and braking conditions.

Calculation on this bases were done and were utilized in MATLAB program

Bottom of Form