Inject Your Horse PART 1, THE PARTS

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Fuel Injection, some are asking “why again?” Well, because many are still intimidated by all this new technology or don’t understand the advantages. So to get everyone up to speed, we are about to start one of the largest series of EFI articles ever published in a magazine. There is so much to write about and space is limited in Bronco Driver, so I can’t fit it all in one issue. This will not be one EFI article thrown together just for the sake of stating “we’ve covered it.” The Bronco Driver staff and I have a desire to give you the absolute best. So our goals for the next few months will be as follows:

- Explain some fundamentals of how it works
- Plan a fuel injection swap for the best results
- Swap an EFI 302 into a 1966-77 Bronco
- Swap an EFI 460 into a 1978-79 Bronco
- Upgrade a stock EFI engine for more performance
- Answer important questions along the way

The goal to accomplish in *this* article is to bring as many people as possible up to the same level of understanding. To avoid answering answer a thousand help letters, I’m going to start at the beginning like we should.

Why fuel injection, and why Ford’s fuel injection? I can’t answer that without starting debates and holy wars, but you still deserve a real answer. A stock 1970 Bronco 302 is rated at 140HP/233ft/lbs; while a 1990 Mustang 5.0L is rated 215HP/285ft/lbs. Ford EFI can be had at 1/3 the cost of aftermarket EFI systems. Peace of mind: not many fathers buy undependable cars for their daughters, so why should you drive one? Ford is leading other manufacturers in EFI technology development; they spent millions upon millions of dollars making sure this was the ideal system. No other system in its class has its capabilities. It can operate upside-down, even if your oil pump can’t. It will never suffer from vapor lock. Hundreds of aftermarket venders have products available for Ford’s EFI, and your closest parts stores have parts and support in stock. Now don’t send the editors hate mail because I said it’s the best. I didn’t say that, but I can prove it better than most, and this isn’t the forum for that debate.

Let’s talk about the parts, what they do, and how they all get along. Do not expect an in-depth text book of knowledge here. If you crave more information than what is here please visit www.fordfuelinjection.com or purchase one of the many books out there. Breaking the EFI system into groups helps to identify parts and makes it easier to learn. There is a computer which acts as a brain and runs the show. There are sensors which serve as eyes and ears to communicate data to the computer. Lastly but never at the bottom are actuators, which serve as the muscles to enforce the commands of the computer.

When you look at the common Ford computer don’t think about your home computer; this one needs almost no attention. To keep it short and sweet this computer has chips for memory, micro-relays to control actuators, a processor to run the show, and a program to keep it all working smoothly. It looks to sensors to learn what environment the engine is operating in. It also looks at driver inputs to learn what you want to do. It processes the information it receives and calculates what the best fuel mixture and timing setting should be. It then activates those actuators to implement the previously calculated fuel mixture and timing. It cycles back to listen to the sensors again to insure the outcome was what the driver and computer wanted. All that happens in a millisecond and repeats at speeds so fast it can adjust calculations between firing cylinders at 6000+RPM. When it’s all working in harmony it will last for over 30 years with only basic maintenance.

Now the rest of this will require some participation on your part. I don’t like homework either, but this is the absolute simplest way EFI can be explained without losing all the important parts. The following tables include the individual sensors and actuators used in Ford’s common EFI. Read each part for a basic explanation, and then review it all to understand how it all interrelates.

The Sensors

Unlike carburetors we have to pick one type of air flow characteristic to dictate fuel management electronically. This air flow measurement usually gets translated into engine load. Engine load is the measurement of how hard an engine is working and is measured in percent. Coasting down hill closed throttle is considered very low engine load. Pulling a weighted trailer uphill at full throttle is considered high engine load.

There are 4 different types of Load (or airflow) measurement, only 2 of which Ford has focused on and we can utilize. Speed Density (SD) uses a MAP sensor to measure engine vacuum; and Mass Air Flow (MA) which uses a MAF sensor to measure the actual weight of air. There are computers that use one or the other, so you must shop carefully. MA is usually the most desirable system to have, but not always, for more on this visit www.fordfuelinjection.com or rush to the mail box for the next issue of Bronco Driver.

Manifold Absolute Pressure sensor (MAP)

This sensor measures the vacuum between the intake valves and throttle body. The manifold vacuum is cross referenced with engine temp in a table; plot where the vacuum and temp meet in this table gives us our base fuel ratio. For this system to work Ford had to measure the actual fuel requirements of the engine.

Mass Air Flow sensor (MAF)

This sensor uses a heated wire to actually measure the weight of incoming air. The cooler the wire becomes, means more air is passing it, into the engine. Once the mass of incoming air is known, calculating fuel ratios is almost perfect. The air mass is crossed referenced with engine temp in a table; again plotting where in the table temp and air mass meet gives us base fuel ratio.

Stator

This sensor tells the computer engine rotation. It sits under the distributor cap and picks up a signal from a wheel with teeth. The wheel has the same number of teeth as cylinders in the engine. Seven teeth are the same and the #1 cylinder tooth is smaller to identify firing order. This is the most important sensor. Without it working properly the computer never senses the engine moving and the entire vehicle is a paper weight.

Throttle Position Sensor (TPS)

Self explanatory, it measures how far you push the skinny pedal. This tells the computer how aggressively we want to drive, the computer is programmed to enrich fuel mixtures the further the throttle is opened. Just like an accelerator pump in a carburetor. Programming also alters the timing more aggressively to match. This sensor is very important in clueing the computer to future events, as it responds quicker to driver changes than any other sensor.

Engine Coolant Temp sensor (ECT)

This measures the temperature of engine, and has a great impact on fuel ratio. This makes simple work of enriching the mixture on start up, overheating, and full throttle fun. It also allows us to lean out the mixture at certain times, to shorten the time it takes to warm up the engine helping us get great fuel economy.

Air Charge Temp sensor (ACT)

This measures the temperature of the air entering the engine. Which impacts the fuel ratio; the cooler the incoming air is the denser it is. Denser air can utilize more fuel, giving us even greater accuracy in obtaining our desired air to fuel ratio.

Barometric Pressure sensor (BP)

This sensor measures the pressure of the outside air. This allows you to drive from Death Valley, California to Denver, Colorado. Keeping fuel ratios perfect for each elevation along the trip. This is something carbs could never do. Speed density systems re-use the MAP sensor to obtain this data prior to start up.

Heated Exhaust Gas Oxygen sensor (HEGO)

This sensor measures the oxygen content in the exhaust gas. This sensor is for feedback, it tells the computer when the air to fuel ratio is above or below 14.7:1. Sometimes the computer is attempting this mixture and sometimes it ignores the HEGO. For more, please seek further reading on the web or in books.

Vehicle Speed Sensor (VSS)

Self explanatory, it tells the computer how fast you are going. This allows certain emissions functions to be operated while on the highway. Also effects fuel delivery during deceleration.

Actuators

Fuel Pump(s)

A pump that pushes fuel from the tank to the injectors at pressures above 50PSI.

Fuel Rail

A tubular spider that connects all the injectors to the main fuel line. This rail operates a recalculating fuel system. This shunts any and all debris or air back to the tank, for a constant supply of fuel.

Fuel Injectors

These are miniature electrical valves, which open and close to exact tolerances, metering fuel in exact amounts as commanded by the computer. They allow extreme accuracy in achieving calculated fuel ratios. They are mounted in the intake just before the intake valves, which improves fuel atomization.

Fuel Pressure Regulator

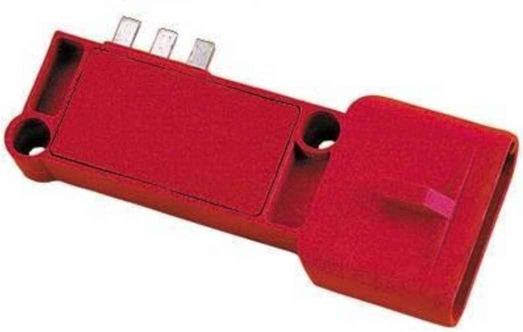
A small device that adjusts the fuel pump's output pressure to a more consistent pressure for the injectors.

Throttle Body

A butterfly valve that allows air into the engine as the gas pedal and throttle cable are depressed.

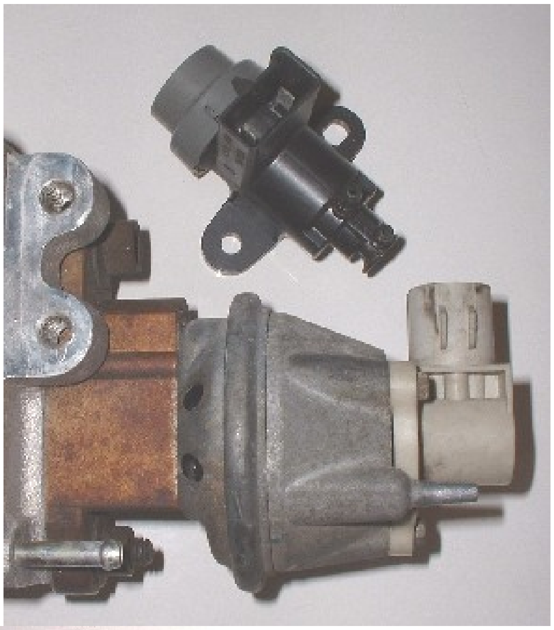
Idle Air Bypass (IAB)

This electrical valve allows air to flow around the throttle body giving the computer control to stabilize the engine RPM. This advancement made no-touch starting possible. Keeps the engine spinning smoothly even with the A/C on and if you brake in a panic.



TFI Ignition Module

This takes the commanded distributor timing from the computer and activates the coil. This advancement allows us to control and monitor timing without relying upon engine vacuum or weights.



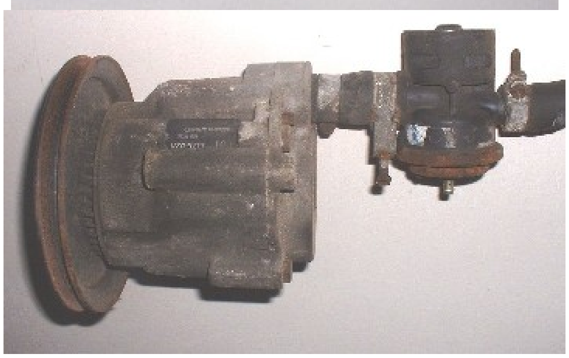
Exhaust Gas Recirculation (EGR)

I will lump this emissions devise into one explanation. It allows already burned exhaust gases to re-enter the intake. This Inert exhaust gas does not need fuel and increases economy. There are 3 parts to this system.

EGR valve, which is the actual component that allows gas to flow from the exhaust to the intake. It is normally closed, and engine vacuum opens it when needed.

EGR Vacuum Regulator, which is the computer's actuator. The computer tells this when to give vacuum to the EGR.

EGR Position sensor, which tells the computer when it is open and how far it is open. All 3 work together to help economy and emissions on the highway



Thermactor Air

This is a combination of parts that pump fresh air into the exhaust. This fresh air allows remaining flammable gases to continue braking down into less harmful gases. Air can not be pumped continually into one section of the exhaust without creating dangerous levels of heat. So the computer shunts the airflow to different parts of the exhaust and vents the air to the atmosphere in intervals. Pure emissions and not highly important for EFI swaps.

With all that covered you may notice that each part of the system has a unique job to perform. These single task items allow better performance, easier diagnosis and repair if the need ever arises. Fuel system problems do not require the entire system to be worked on or even removed in most cases. I like to think of EFI as a giant road map kids play with on the floor.

Sorry for the seemly slow start but now that we all have an idea of how it works, come back next time. We will be collecting all the parts needed to install EFI engines into our project Broncos, and preparing the vehicle and parts we collected for the swap. We may move a little further along depending on how much space is allowed. Some of you are half way into the EFI swap. If you can't wait until the next issue is in your hands stop by www.fordfuelinjection.com for details on this swap. So stay with us as we inject your horse.