Extra Injector Controller

A DIY extra injector controller.

By Fernando Hood

AutoSpeed reader Fernando Hood has developed a programmable extra injector controller and here's an overview of it.Note that the software and hardware presupposes a familiarity with both electronics and programming. Technical support for this project should be sought fromhoodey@hotmail.com and not from AutoSpeed.

Fuel Enrichment Options

There are a number of ways to increase fuelling on cars which have been turbocharged or which have had an increase in boost. Some enthusiasts have used the water temperature sensor to increase the fuel delivery. This is done by reducing the resistance of the sensor, thereby tricking the ECU into thinking that the engine is cold.

A pressure switch is often used to trigger the lower resistance. Another method is to use an extra injector wired in parallel with one of the factory injectors and triggered by a boost switch.

The problem with these methods is that they're really crude. The ECU reads all the sensors and is able to pulse the injectors correctly. You are suddenly accelerating at 3000rpm and the boost gauge reads 4 psi. At a mere 3000 rpm and 4 psi the ECU is in total control of the situation. However, the pressure switch triggers and suddenly you may have too much fuel. In other words, the extra enrichment is not proportional to the actual load. On the other hand, an aftermarket computer is ideal - but only if you have a nice budget and you have good technical skills and an in-depth knowledge of engine tuning.

What is Required?

Most of us have heard the term 'mapped' injection but may not understand what this actually is. While the engine is running, its requirements for fuel and ignition timing will vary according to certain engine conditions, the main two being engine speed and engine load. A 'map' is no more than a lookup table with data giving the appropriate fuel or timing setting for each possible speed and load condition. There will be a map for the injector openings (fuel map) and a separate map for the ignition timing settings (ignition map) within the ECU. Each map has entries for a pre-determined range of engine speeds (called speed sites) and a predetermined range of engine load conditions (called load sites). The ECU knows the engine speed (derived from the crank sensor or distributor pickup) and the engine load (from the MAP sensor or airflow meter) and uses these two values to 'look-up' the appropriate fuel and timing settings in each map.

In a modified car, a flexible system is required which will start adding extra fuel as soon as the stock system becomes incapable of maintaining the correct air/fuel ratio. If for example, the engine is at 5000 rpm and on 1 psi of boost, and the ECU can supply the correct A/F ratio, then the extra fuel system should not intervene. However if the engine is at 5000 rpm and 8 psi and the A/F ratio is becoming too lean, then it will be required to supply extra fuel. Also, if the pressure increases to 11 psi (at the same rpm) it should be able to supply more fuel than at 8 psi.

In summary, we need to supply fuel based on boost pressure and engine RPM.

The Inputs

The controller must read the pressure in the intake manifold as well as the engine RPM. These signals must then be converted to a form that a micro-controller can understand. In my system there is one fuel table for each 1000 rpm value from 3000 to 7000 rpm. Each table has eight entries representing an injector pulse value between 1 and 125. The value represents one clock pulse. 125 represents 125 clock pulses which is equivalent to 4 milliseconds.

3000 rpm Table							
1	2	3	4	5	6	7	8
10	20	30	40	50	60	70	80

Above is the 3000rpm table which is indexed by boost pressure. An engine speed of 3000rpm and boost pressure of 7psi will produce an injector pulse of 70. Therefore by changing the values in the different rpm tables, a fuel map based on rpm and boost can be achieved.

Sensors

A Manifold Absolute Pressure (MAP) sensor is used to measure the boost pressure in the manifold. It is a 3 Bar sensor which can measure boost pressure from atmospheric to 30 psi. The MAP sensor produces 1.27V at atmospheric pressure and 2V at 6 psi of boost. At idle it generates a voltage of 0.5V when the vacuum is very high.

The crank angle sensor is located in the distributor. It is a magnetic pickup and produces pulses that are used by the ECU to control the firing of the injectors. This sensor feeds a frequency to voltage device which translates how fast the engine is turning into a voltage. The higher the engine speed, the higher the voltage.

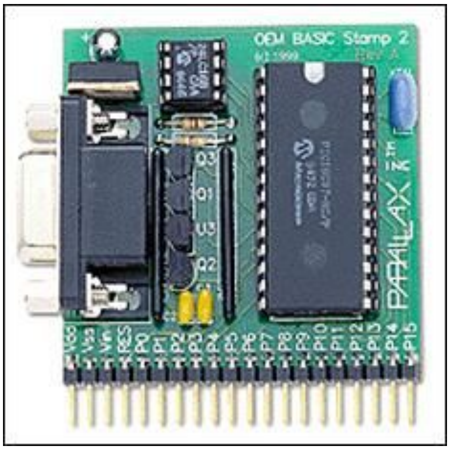
RPM	**MilliVolts**
1000	220
2000	420
3000	640
4000	800
5000	1050
6000	1210
7000	1510

The selection of a resistor and capacitor will determine how voltage changes in relation to engine speed. If you use capacitors and resistors that are too big, the maximum voltage will be reached before the engine reaches maximum rpm. The frequency to voltage converter is also independent of supply voltage, which makes measurements of rpm very accurate.

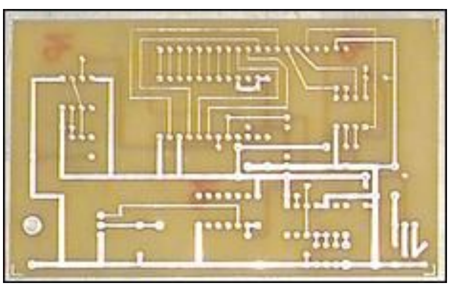
The voltages must be converted to a form that the computer can understand. A computer can only understand 1's and 0's. This is where the 12-bit analog to digital converter comes to play. It can measure a 5-volt source and convert it to a value of 111111111111 which is the equivalent to 4096 in decimal. Zero volts will be read as 000000000000. This device can measure voltages as small as 2/1000 of a volt.

The result of the conversion after reading pressure is used to create a pressure index. One psi = 1, two psi = 2, seven psi = 7 etc. These are used to index the rpm tables. The rpm value from the conversion is used to select the correct rpm table. Once the correct rpm table is located, the index value returns the injector pulse value which is passed to a Programmable Interval Counter. When a count is written to one of the counters it will start counting to zero once the counter has been triggered. Its output will go to zero while counting and will return to high once it reaches zero. The different count values can then determine how long the output stays at zero. This output is passed to a power transistor which is used to drive the injector. The trigger for the counter comes from the ignition coil but must be cleaned up before it is passed to the interval timer.

The interval counter is very sophisticated. It has three independent 16 bit counters. However 8 bits can be used for counting. 8 bit in binary is 11111111 or 256 in Decimal. A value of 256 represent 8ms however we only have 4ms to inject fuel. The beauty about the counter is that once it is triggered the micro-controller can return to measuring the RPM and boost pressure. It is therefore possible to update the injector every engine revolution which is more than adequate.



This is the micro-controller that can plugs directly into the system board. This can be bought as a kit for US$34 at www.parallaxinc.com. You should make sure to order the cable that goes from the computer to the micro-controller.



This is the system board that is a available from me at hoodey@hotmail.com. All of the components which go on this board are easily available at any electronics store for under US$30.

Extra Injector

The extra injector is plumbed into the intake tubing and is aimed at the throttle body to ensure thorough mixing with the air. It is fed from a T-junction on the fuel rail.

The injector will have to be sized based on the extra air flowing into the engine. Currently a 210cc is being used in my Suzuki Swift GTi to supply enough fuel for 30hp. The stock ECU will be able to supply enough fuel for at least 15 more horsepower over stock so the extra injector will have to make up the difference. The injector is a peak and hold injector which are the ones with the lower resistance. These are said to have a better response time than the high resistance injectors.

It is proposed that later versions of the system board will allow for the following:

- Monitoring of the duty cycle of the OEM injectors.
- Ability to drive more than one injector.
- The magnetic pickup will no longer be used for speed sensing. This will allow interfacing to any type of vehicle with an ignition coil.
- Addition of Peak and Hold Circuitry to save power and offer better control of injector.

Installation Example: Suzuki Swift GTi

This photo shows the injector controller mounted in a Suzuki Swift GTi. It is wrapped in foil to reflect heat from the engine bay. This injector setup ensures that fuel properly mixes with the air before it reaches the cylinders.

Here the two wires (red and green) feed the controller with a frequency from the magnetic pickup in the distributor. This allows the controller to determine the engine speed.

The trigger for the injectors taken from the coil terminal to ensure the injector is fired on each induction stroke. The fuel for the fifth injector can be seen being taken off the fuel rail using a brass T-junction.

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