Hydrogen fuel enhancement for vehicles

History

1975

Research in 1975 examined hydrogen enhanced gasoline in lean combustion.[John Houseman and D.J Cerini of the Jet Propulsion Laboratory produced a report for the Society of Automotive Engineers titled "On-Board Hydrogen Generator for a Partial Hydrogen Injection Internal Combustion Engine", and F.W. Hoehn and M.W. Dowy, also of the Jet Propulsion Lab, prepared a report for the 9th Intersociety Energy Conversion Engineering Conference, titled "Feasibility Demonstration of a Road Vehicle Fueled with Hydrogen Enriched Gasoline."[

2002

Research done in 2002 shows that the "addition of hydrogen to natural gas increases the burn rate and extends the lean burn-limit". Also concluded was that "hydrogen addition lowers HC emissions", and with properly "retarded ignition timing" also reduces NO_x emissions.

Further research in 2002 achieved results showing "a reduction of NO_x and CO_2 emissions", by modeling an on-board hydrogen reformer and "varying the efficiency".[The research was specifically a "numerical investigation" done to "forsee performances, exhaust emissions, and fuel consumption of a small, multi valve, spark ignition engine fueled by hydrogen enriched gasoline".[

2003

In 2003 Tsolakis et al. of the University of Birmingham showed that "partial replacement of the hydrocarbon fuel by hydrogen combined with EGR resulted in simultaneous reductions of smoke and nitrogen oxides emissions (NO_x) without significant changes to engine efficiency". Similar results have been presented by a team of scientists from Zhejiang

University, China, which found that "a little amount of hydrogen supplemented to the gasoline-air mixture can extend the flammability of the mixture... improving the economy and emissions of engines".

2004

Test results in 2004 show "that the H_2-rich reformate gas was an excellent NO_x reductant, and can out perform raw Diesel fuel as a reductant in a wide range of operating conditions".This is referring to Diesel fuel being used in excess, as a reductant, to cool the combustion reaction, which indeed has a mitigating effect on NO_x production.

In 2004 research was conducted concluding that an "SI engine system fueled by gasoline and hydrogen rich reformate gas have been demonstrated" to achieve a "dramatic reduction of pollution emissions".This was achieved by "extending EGR operation" in addition to consuming "gasoline and hydrogen rich reformate". Emissions results show that "HC-emissions as well as NO_x-emissions could be reduced to near zero". Overall a 3.5% reduction in CO_2 emissions was achieved during the "FTP test cycle". The research also concluded that the exhaust after treatment system can be simplified, "resulting in cost reduction for the catalysts".

To date, Hydrogen fuel enhancement products have not been specifically addressed by the EPA. No research devices or commercial products have reports available as per the "Motor Vehicle Aftermarket Retrofit Device Evaluation Program. In general there are no references available for the US Government addressing the concept of hydrogen fuel enhancement.

http://en.wikipedia.org/wiki/Hydrogen_fuel_injection

The Theory behind hydroxy boosting in vehicles

Hydrogen fuel enhancement is a term used to describe the supplementation of an internal combustion engine (ICE) with hydrogen to improve fuel efficiency and power. By supplementing an engine's normal fuel with hydrogen / compressed natural gas blends (H2CNG or HCNG), the exhaust emissions of the ICE can be dramatically improved.Hydrogen injection is similar to both propane injection and nitrous oxide injection.

HCNG (or H2CNG) is a mixture of compressed natural gas and 4-9 percent hydrogen by energy. Hydrogen contents of less than 50% in the HCNG blend have leakage and flammability risks similar to those of CNG alone. With the hydrogen being part of the mixture, there are no special precautions needed to avoid hydrogen embrittlement of the materials coming in contact with the mixture.. HCNG stations can be found at Hynor (Norway) and the BC hydrogen highway in Canada.

Automotive fuel enhancement systems inject either a hydrogen-rich mixture, or pure hydrogen into the intake manifold of the engine. In some cases, this is combined with air/fuel ratio and timing modifications. A small amount of hydrogen added to the intake air-fuel charge permits the engine to operate with leaner air-to-fuel mixture than otherwise possible. As the air/fuel mix approaches 30:1 the temperature of combustion substantially decreases effectively mitigating NO_x production.

Under idle conditions power is only required for extraneous components other than the drive train, therefore fuel consumption can be minimized. A 50% reduction in gasoline consumption at idle was reported by numerically analyzing the effect of hydrogen enriched gasoline on the performance, emissions and fuel consumption of a small spark-ignition engine.

Under most loads near stoichiometric air/fuel mixtures are still required for normal acceleration, although under idle conditions, reduced loads and moderate acceleration hydrogen addition in combination with lean burn engine conditions can guarantee a regular running of the engine with many advantages in terms of emissions levels and fuel consumption.

Increases in engine efficiency are more dominant than the energy loss incurred in generating hydrogen. This is specifically with regard to use of a hydrogen reformer. Overall computational analysis has marked the possibility of

operating with high air overabundance (lean or ultra-lean mixtures) without a substantial performance decrease but with great advantages on pollution emissions and fuel consumption.

Overall comparing the properties of hydrogen and gasoline, it is possible to underline the possibilities, for hydrogen fueled engines of operating with very lean (or ultra-lean) mixtures, obtaining interesting fuel economy and emissions reductions.The concept of hydrogen enriched gasoline as a fuel for internal combustion engines has a greater interest than pure hydrogen powered engines because it involves fewer modifications to the engines and their fueling systems.

Hydrogen fuel enhancement from electrolysis of water can produce fuel efficiency improvements on the order of 4% and similar modest reductions in emissions, and is currently in use in Canada

A simplified single-step combustion reaction is represented as:

$$[\text{FUEL}] + [\text{HYDROGEN}] + [\text{AIR}] \rightarrow \text{HC} + \text{CO} + \text{CO}_2 + \text{H}_2\text{O} + \text{NO}_x$$

http://en.wikipedia.org/wiki/Hydrogen_fuel_injection

Oxyhydrogen

Oxyhydrogen is a mixture of hydrogen and oxygen gases, typically in a 2:1 atomic ratio; the same proportion as water. At normal temperature and pressure, oxyhydrogen can burn when it is between about 4% and 94% hydrogen by volume,[3] with a flame temperature around 2000 C.

http://www.hhogasgenerator.com/

Modifying the Vehicle's ECU to Accommodate the New Mixture

Many people have been experimenting with systems in which an on-board electrolizer, using the vehicle's battery power, converts water into a hydrogen-oxygen gas, which they then duct into the engine's air intake, where the hydrogen catalyzes a more efficient burn of the fuel, resulting in significant mileage increase, torque increase, and a reduction in emissions. Some entities have been commercializing various iterations of this approach, providing everything from plans and kits to completed systems and installation.

In general there are two components to hydrogen addition that effect efficiency. First is flame velocity, which provides more time for the fuel to burn between valve cycles. Second is the lean burn limit, in which gasoline does not like to remain flammable past a certain point. Leaning the air/fuel ratio results in less fuel being injected therefore less engine power output. The lean condition uses excess air to quench combustion temperature, which reduces NOx production. For performance purposes the engine should be tuned to use ultra lean conditions only when substantial power output is not required, therefore maintaining peak power output when necessary. Hence lean conditions will only be used during idle, moderate acceleration and cruise. Basically this is all defined in the fuel maps of the ECU, and there are many consideration in how to program them. Fuel enhancement allows for different options to consider when tuning the vehicles fuel maps. Also in automatic vehicles the shift points of the transmission can be calibrated to increase the average time the engine is operating in an efficient RPM region.

Increasing gas mileage depends on changing how the engine is operating. To do this the primary component that needs modification is the ECU or the carburetor. Stock ECU's are designed by OEM manufacturers such as Bosch, and are not modifiable. Only a couple of hacks, and chips are available to tweak stock ECUs, with the best and most effective course of action being complete replacement with an aftermarket tunable ECU.

The optimal implementation of fuel enhancement requires injection of predefined quantities of hydrogen depending on conditions (RPM, load, etc..). Different quantities of hydrogen injection will have a different effect, and should be reflected in great detail in the ECU's fuel maps. Such customization requires at minimum a dynomometer, and hopefully a pyrometer tapped into each cylinder of the engine.

http://peswiki.com/index.php/Article:Modifying_the_Vehicle's_ECU_to_Accommodate_a_New_Mixture_from_Hydrogen_Boosting

Hydrogen Injection Methods

The actual increase from hydroxy injection, also called HHO, hydro-boost, and hydrogen boost; is probably more in the region of 15-30%. When combined with other things such as proper tire inflation, better driving habits, lubricant additives for the oil, preheating of the fuel (very dangerous), then it is conceivable that consistent 50-60% improvement could be achieved.

New Energy Congress member, Tai Robinson argues for having hydrogen tanks on board to inject H in proportion to the torque requirements of the vehicle (governable), rather than via onboard electrolysis, which is not governable, and is prone to be more dangerous because of the tendency of the H-H-O mixture to want to expolosively recombine into water. An argument against that system would be the up-front cost; and the potential danger of the hydroxy gas can be mitigated by a flash-back arrester or a bubbler.

LPG Assist

Diesel/Gas Australia (*http://www.dieselgasaustralia.com.au/default.aspx?ID=Vehicles*) - This company has been able to do a fuel aspiration into the air intake for diesels. Normally, this is a dangerous condition, as once the heat of compression reaches the autoignition point of the fuel, uncontrolled combustion takes place, often well before top dead center. This system does not do it at all, which is amazing. Vaporized LPG is introduced into the air intake to augment the normal diesel fuel injection into the cylinder. The result is cleaner combustion and higher overall fuel mileage. -- Ken Rauen, Feb. 6, 2006

- **GreenPower Bi-Fuels (*http://www.gpbf.co.uk/bifuel.htm*)** - Bi-fuel is the principle of running two fuels in an engine simultaneously. Introducing a small amount of LPG (Liquid Petroleum Gas) into a diesel engine via the air inlet manifold has the effect of acting as a catalyst, causing the diesel to combust more effectively, burning more of the diesel.

Metalurgical

- **AEC's New Initiative Produces Hydrogen-on-Demand for Air Intake (*http://pesn.com/2008/02/01/9500470_AlternateEnergyCorp_hydrogen-injection/*)** - Differing from the various electrolysis-based hydrogen-injection approaches being pursued, Alternate Energy Corp. has a proprietary hydrogen-on-demand system that is metallurgical based. (*PESN*; Feb. 1, 2008)

Electrolysis Units

On board electrolysis of water produces hydrogen and oxygen which are added to the air/fuel mixture to increase combustion efficiency. Also known as Brown's gas or egas (electrolysis gas or electrolytic gas). Systems that produce

less than approximately 25 liters per hour require oxygen sensor override (*http://www.eagle-research.com/fuelsav/efie.html*) to work properly.

http://peswiki.com/index.php/Directory:Fuel_Efficiency_Hydrogen_Injection

A converter separates water into a gas called HHO (2 hydrogen atoms and 1 oxygen atom) HHO gas is also known as browns gas or simply hydroxy. using the electricity from the battery of the vehicle. A converter produces hydrogen that is required by the vehicle. This gas is called Brown Gas, which burns smoothly. It delivers the atomic potency of hydrogen and also retains the stability of water. Once burned as fuel in the vehicle the end product is H2O! It is easy to install, affordable and a quart of water can last for months. HHO is a form of gas created by electrolysis. Ordinary water contains a ton of energy, but the trick is to get that energy out without using a lot of energy to do so. The creation of pure hydrogen gas is impossible. As of now, it is not even economical for large corporations

http://www.articlesbase.com/cars-articles/cut-your-gas-costs-480671.html
http://www.articlesbase.com/automotive-articles/hho-gas-car-kit-plans-increase-gas-mileage-435030.html

Aluminum Oxidation

Aluminum is oxidized in a chemical reaction that releases hydrogen gas.

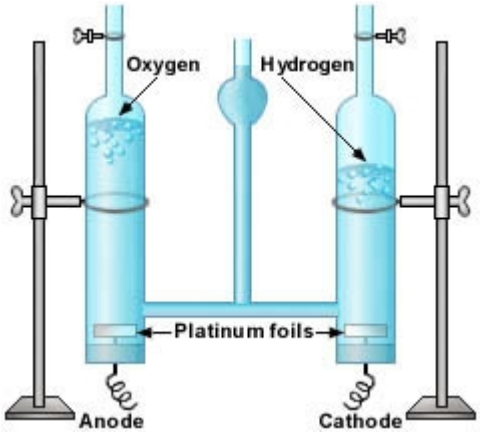
- **AllH2 Just Add Water** (***http://www.allh2.com/1086034.html***) - Increase your gas mileage by 40 % or more. It takes only 3 hours to install the conversion kit to your car's existing fuel system. It modifies the car to idle on hydrogen and accelerate on gasoline. The galvanic hydrogen producer generates hydrogen from seawater. This cell is a combination of magnesium, aluminium and stainless steel.
- **h2gen.info** - Hydrogen Generator working prototype for automobile engine shows improved gas mileage.
- **Beverage can hydrogen** (***http://www.green-trust.org/2005/09/beverage-can-aluminum-hydrogen.html***) article.
- **A chemistry lesson** (***http://www.newton.dep.anl.gov/askasci/chem00/chem00831.htm***)

Other Innovations

- **QSI-Nano® NiFe Product Profile Hydrogen Generation Electrodes** (***http://www.qsinano.com/white_papers/QSI_DSE_Hydrogen_PPT_March_07.pdf***) - (36-page PDF) QSI (*http://www.qsinano.com/apps_hgen.php*) has demonstrated that by using its nano nickel and iron particles it is possible to exceed the Department of Energy's target with 85% energy efficiency by increasing the surface area of the active components of the hydrogen electrolyzer, without any CO2. (*Quantum Sphere*; May 1, 2008)

http://peswiki.com/index.php/Directory:Fuel_Efficiency_Hydrogen_Injection

Electrolyzer build process



One important use of electrolysis of water is to produce hydrogen.

$$2H_2O_{(l)} \rightarrow 2H_{2(g)} + O_{2(g)}$$

This has been suggested as a way of shifting society toward using hydrogen as an energy carrier for powering electric motors and internal combustion engines.

http://www.answers.com/topic/electrolysis

Actually, water is "burned hydrogen" or "hydrogen ash". Water is the by-product resulting from operating a vehicle on hydrogen. In more technical terms, then, water is a lower energy form of hydrogen. To turn water back into a fuel, energy must be pumped into the water causing it to dissociate, freeing the hydrogen. For this reason, we do not consider hydrogen to be a source of energy. It is, rather, an energy vector--a convenient form of energy that can be stored safely and then used efficiently without jeopardizing the environment.

The simplest process for dissociating water employs the use of electrical energy and is known as electrolysis. When twometal plates are placed in water in the presence of a catalystand connected to a source of electricity, water molecules are
pulled apart into hydrogen and oxygen. Hydrogen bubbles collect on the negative plate (cathode) while oxygen bubbles gather on the positive plate (anode). Since hydrogen and oxygen exist in water at a ratio of two to one, twice as many hydrogen bubbles form as oxygen bubbles. Equipment to commercially separate water into hydrogen and oxygen has been on the market for many years. This electrolysis equipment utilizes various schemes and technologies to
increase the quantity of hydrogen produced per unit of energy consumed. The measure of hydrogen produced by an electrolyzer verses the electricity consumed is referred to as the electrolyzer's efficiency. If the amount of hydrogen produced by an electrolyzer were exactly equivalent to the
electrical energy put into the unit, then the device would be said to be 100 percent efficient. In reality, commercial electrolysis equipment ranges in efficiency from 40 to 80 percent.
Each electron which is passed through water in an electrolysis device liberates one atom of hydrogen. Two electrons, then, produce one hydrogen molecule (H2). Avogadro's number of electrons (6.02 x 1023) produces one gram of hydrogen. Since each electron produces one hydrogen atom, the efficiency of
an electrolysis device can be determined by measuring the electric voltage required to operate the cell. A cell operating at the theoretical voltage of 1.23 volts is 100 percent efficient. The amount of voltage above 1.23 required to operate the cell is wasted. The objective, then, is to make a cell that will operate
as close to this voltage as possible.

http://www.billingsenergy.com/Research/HWV-Chapter_09.pdf

Distilled or de-mineralized water is added to the hydrogen generator once every tank full of fuel and is usually done when checking your oil. If the water is not added no damage is done to the engine or to the hydrogen generator (electrolyzer). Mineral water should not be used because the minerals will stay behind in the electrolyzer and eventually you will have mud inside. Distilled water can be purchased at Walmart for 64 cents per gallon. Rain water can be used, as well as air conditioner drippings. It only uses 12-16 ounces of water every tan full of gasoline. If you use mineral water, it will cloud up, get muddy and cause the electrolyte to need rinsing or cleaning out in weeks or months. You can use de-mineralized tap water if your city pipeline gets filtered.

http://www.mimousa.com/hydrogen/installation.asp

When an electrolysis solution is placed in the body, and a current provided across the electrodes, water is caused to decompose into hydrogen and oxygen. These combustible gases are then passed into the internal combustion engine to increase the efficiency and power thereof. In one embodiment a reservoir is provided to ensure that the level is maintained in the cell. Safety features include a low level sensor switch and low level shut off, a temperature sensor and high temperature cut off, and a pressure sensor and high pressure cut off.

http://www.freepatentsonline.com/6209493.html

- ## The plate conditioning process

Electrolysis of water can be observed by passing direct current from a battery or other DC power supply (e.g. computer power supply 5 volt rail) through a cup of water (in practice a saltwater solution increases the reaction intensity making it easier to observe). Using platinum electrodes, hydrogen gas will be seen to bubble up at the cathode, and oxygen will bubble at the anode. If other metals are used as the anode, there is a chance that the oxygen will react with the anode instead of being released as a gas. For example using iron electrodes in a sodium chloride solution electrolyte, iron oxide will be produced at the anode, which will react to form iron hydroxide. When producing large quantities of hydrogen, this can significantly contaminate the electrolytic cell - which is why iron is not used for commercial electrolysis.

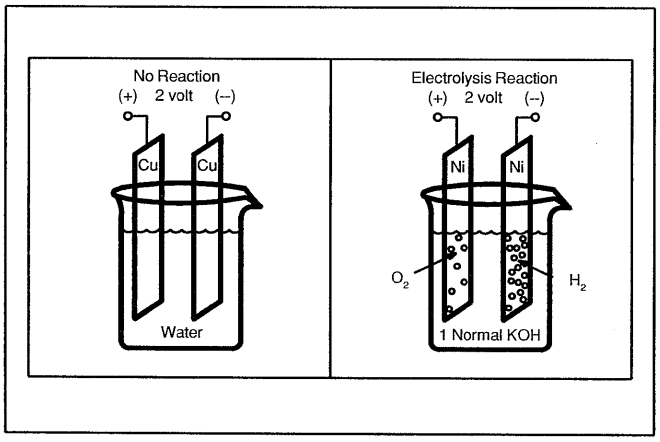
The energy efficiency of water electrolysis varies widely. The efficiency is a measure of what fraction of electrical energy used is actually contained within the hydrogen. Some of the electrical energy is converted to heat, a useless by-product. Some reports quote efficiencies between 50 and 70%. This efficiency is based on the Lower Heating Value of Hydrogen. The Lower Heating Value of Hydrogen is thermal energy released when Hydrogen is combusted. This does not represent the total amount of energy within the Hydrogen, hence the efficiency is lower than a more strict definition. Other reports quote the theoretical maximum efficiency of electrolysis. The theoretical maximum efficiency is between 80 and 94%. The theoretical maximum considers the total amount of energy absorbed by both the hydrogen and oxygen. These values only refer to the efficiency of converting electrical energy into hydrogen's chemical energy. The energy lost in generating the electricity is not included. For instance, when considering a power plant that converts the heat of nuclear reactions into hydrogen via electrolysis, the total efficiency is more like 25–40%.

http://www.answers.com/topic/electrolysis

The active surfaces of the plates- that is, the surfaces which are 1.6mm apart from each other, need to be prepared carefully. To do this, these surfaces are scored in an x-pattern using 36-grade coarse sandpaper. Doing this creates miniature sharp crested bumps covering the entire surface of each of these plates. This type of surface helps he hydroxy bubbles breakaway from the surface as soon as they are formed. It also increases the effectiveness area of the plate by about 40%.

http://aquauto.com/sites/default/files/users/Nick_Stone/Chapter10.pdf

FIGURE 9-1: BASICS OF ELECTROLYSIS



First, it is necessary to add an electrolyte to the water. An electrolyte is a chemical which ionizes in the water and facilitates the conduction of electricity through the liquid. Very pure water has an extremely high electrical resistance (in excess of one megohm per centimeter). In a simple electrolysis cell, either hydrochloric acid (HCl) or potassium hydroxide (KOH) can be used as the electrolyte. When even a small quantity of the electrolyte material is added to the water, the electric current begins to flow. The next improvement to lower the voltage is a metallic catalyst. Instead of copper, which is not an ideal material for electrolysis, electrodes of nickel should be substituted. Now when connecting the circuit as shown in Figure 9-1, hydrogen bubbles begin to form at the negative electrode while oxygen bubbles form at the positive electrode.

http://www.billingsenergy.com/Research/HWV-Chapter_09.pdf

Nuclear energy can be used to power a high temperature water electrolysis process, while another uses heat and electricity from solarelectric concentrators.

http://www.nrel.gov/docs/fy05osti/37093.pdf

Bob Boyce's Electrolyzer

It isn't critical how you get the pulses used to modulate the AC on the DC bias; any method will do. A pressure switch is needed to turn the cell off at 5 psi and back on when it falls to 3 psi. Bobs bubbler's have one way valves to retain pressure in the system so that production begins immediately when the system kicks back on. He uses many small holes in his bubbler inlet below the water so bubbles are tiny and diffused. This is to prevent a flashback from firing across several large bubbles back to the cell. Bob said it works well.

Plates are crosshatch sanded using no.80 sandpaper to create masses of points on each plate surface. Plate edges are seal for two reasons; to prevent all the separation from occurring only on the edges, and to prevent current leaking through the water from cell to cell.

Bob says this causes a magnetic circuit through the center of the plates in the electrolyzer. The result of all these refinements is that when the water is split, the bias voltage keeps it from recombining, and H molecules have plenty of electrons to absorb, preventing the two Hs from joining. Thus the extra large volume of monatomic Hydrogen molecules.

Water must be distilled; or clean, spring or rainwater. These last may require several filterings, to remove sludge; much like Joe Cell Charging water. The 6"x6" Plates are spaced 3mm apart exactly and sealed on the sides and bottom. Water levels must be maintained in each cell. Bob's has a supply pipe with holes drilled along it for each cell.

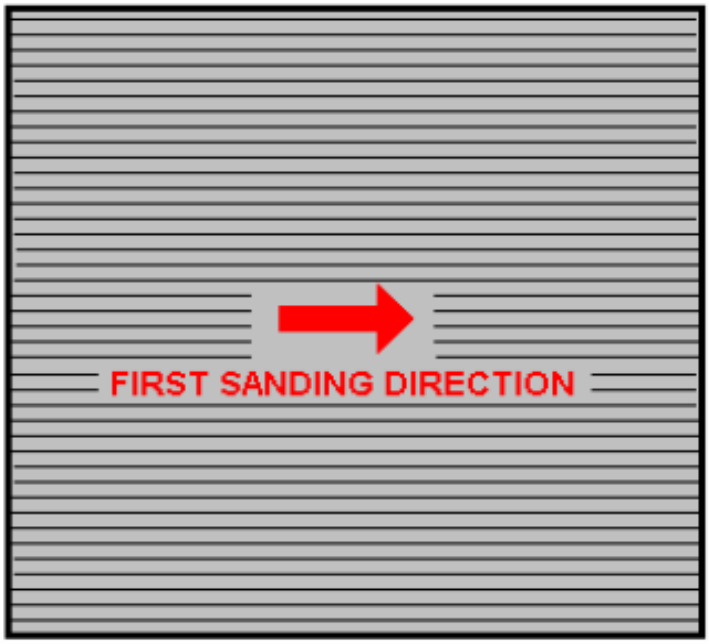
http://pesn.com/2007/01/08/9500445_Bob_Boyce_Electrolyzer_Plans/

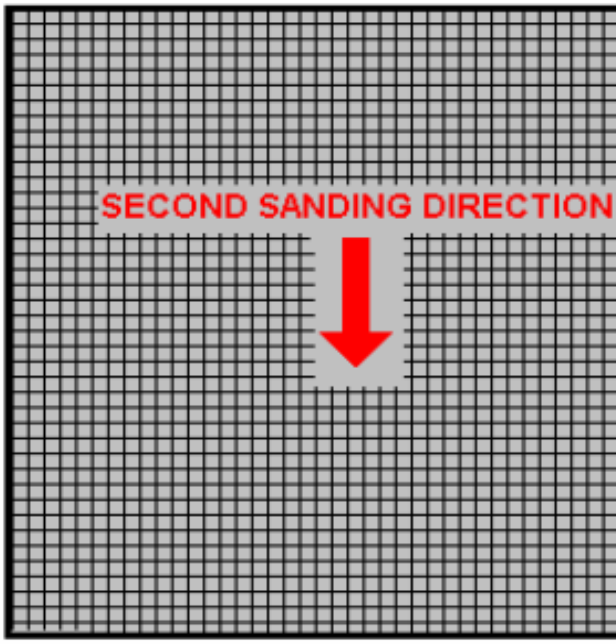
Cleansing process, with NaOH 3% solution. After two or three days of cleansing the unit to remove impurities from the steel plates and box, a ~20+% solution of KOH is used to condition the box in preparation for use either as a booster or in resonance mode for high volume output of hydroxy gas.

Filter material was added to the top of the inside of the box for use during resonance operation. The filter material helps prevent the aqueous solution of KOH from overflowing into the other cells.

http://peswiki.com/index.php/OS:Bob_Boyce_Electrolyzer:Hathaway_Photos

The surfaces are scored an X pattern using a 36 grade coarse sandpaper. Doing this creates miniature sharp crested bumps covering the entire surface of each of these plates. This type of surface helps the hydroxy bubbles to break away from the surface an d also increase the effective surface area of the plate by 40%.



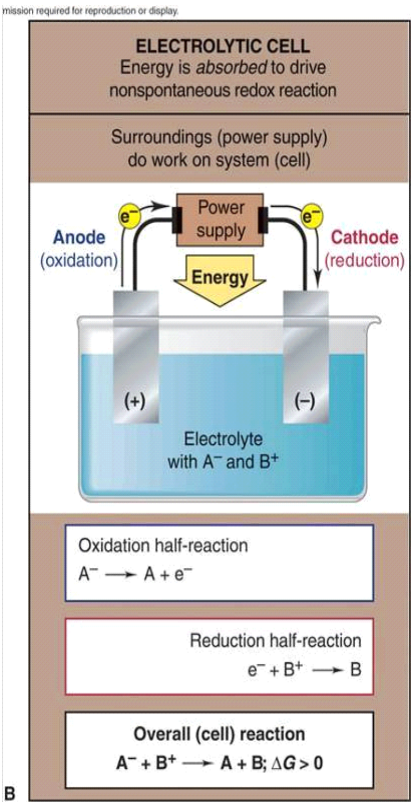


http://aquauto.com/sites/default/files/users/Nick_Stone/Chapter10.pdf

plate cleansing and conditioning is done with a NaOH solution from 5% to 10% in strength.Â A 5% solution ("by weight") is 50 grams of NaOH in 950 cc of water.Â A 10% ("by weight") solution is 100 grams of KOH in 900 cc of water.

http://tech.groups.yahoo.com/group/WorkingWatercar/message/4183

- **Components and definitions.**



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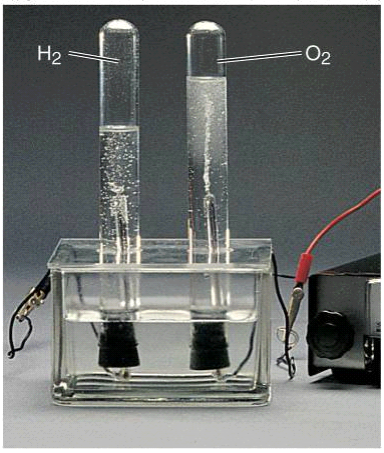
http://www6.ufrgs.br/ct/ntcm/graduacao/ENG06631/25ele.ppt#266,8,Slide 8



Electrolysis of water

Oxidation half-reaction
$2H_2O(l) \longrightarrow O_2(g) + 4H^+(aq) + 4e^-$

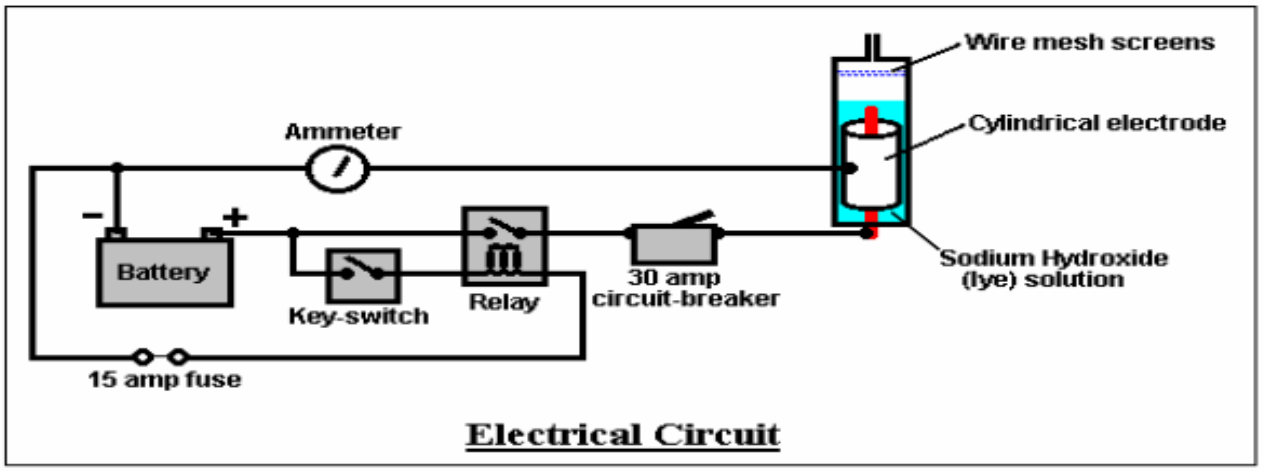
Reduction half-reaction
$2H_2O(l) + 2e^- \longrightarrow H_2(g) + 2OH^-(aq)$

Overall (cell) reaction
$2H_2O(l) \longrightarrow 2H_2(g) + O_2(g)$

17

http://www6.ufrgs.br/ct/ntcm/graduacao/ENG06631/25ele.ppt#279,17,

Electrical circuit of an electrolyzer



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Electrical components

- See “Hardware Components” below

- PWM (pulse width modulator)

  Pulse Width Modulation (PWM) is a common technique for speed control which can overcome the problem of the poor starting performance of a motor.

  A good analogy is bicycle riding. You peddle (exert energy) and then coast (relax) using your momentum to carry you forward. As you slow down (due to wind resistance, friction, road shape) you peddle to speed up and then coast again. The 'duty cycle' is the ratio of peddling time to the total time (peddle + coast time). A 100% duty cycle means you are peddling all the time, and a 50% duty cycle means you are peddling only half the time.

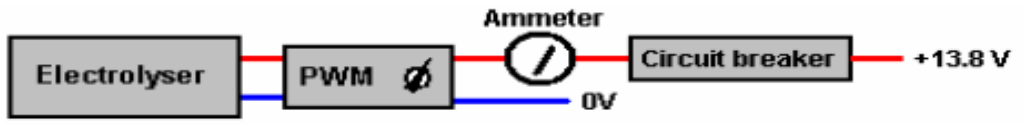
  PWM for motor speed control works in a very similar way. Instead of supplying a varying voltage to a motor, it is supplied with a fixed voltage value (such as 12V) which starts it spinning immediately. The voltage is then removed and the motor 'coasts'. By continuing this voltage on/off cycle with a varying duty cycle, the motor speed can be controlled.

  http://www.eleinmec.com/article.asp?28

As time goes by various inefficiencies of the electrolysis process raises the temperature of the electrolyte. This increases the current flowing through the electrolyzer, which in turn, heats the electrolyser more. This causes 2problems. Firstly the gas production rate at startup is lower than expected as the electrolyte is hot as it will become. Secondly, when the

electrolyser has been going for some time, a temperature runaway effect is created where vapor or steam, neither of which are desirable as they take up space in the cylinder which could have been used for useful fuel

There are various solutions for this situation. One is to accept the gas production will be low in the early stages of each run, and adjust the concentration of the electrolyte so that the maximum running temperature gives exactly the design through the electrolyser. This is not a popular solution, especially with people who make lot of short journeys between long trips. The best solution is to use the highest concentration of electrolyte and an electronic Pulse width modulator circuit to control the current. This rather impressive name means a circuit which switches the power to the electrolyser ON or OFF many times each second, and is the DC version of the dimmer switch used to control lighting levels in the homes. Using this solution an ammeter to show the DC current, and a PWM control knob, are mounted on the dashboard of the vehicle, and the driver lowers the current manually if it start to get too high.



http://aquauto.com/sites/default/files/users/Nick_Stone/Chapter10.pdf

- Schematics

Example 1 : using 555 ICs

The concept of PWM inherently requires timing. Two 555 timer ICs and some potentiometers can be used to generate a PWM signal, and since PWM provides a digital, on/off signal, it is also easy to use a PC or micro-controller to create the signal; however this is beyond the scope of this article.

The circuit in figure 2 uses two 555 ICs and is actually a combination of two types of circuit. The first is a free running multivibrator (astable) with an adjustable frequency around 30Hz. The output of this circuit then triggers a **pulse** shaping (monostable) circuit which adjusts the **width** of the **pulse**. The circuit produces a duty cycle in the range of approximately 0.3% to 97%.

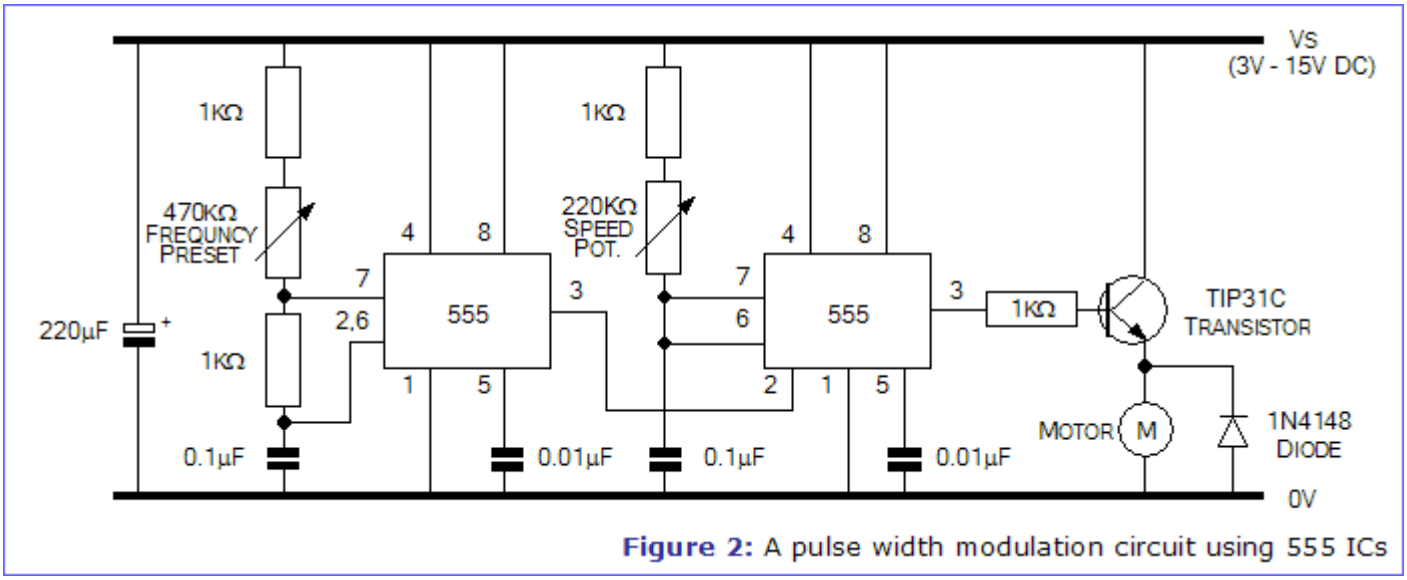


Figure 2: A pulse width modulation circuit using 555 ICs

The speed of the motor is controlled with a single potentiometer (variable resistor). It is possible to run a Meccano M5 motor to test the circuit, and it will run from dead still to full speed using the potentiometer speed control and a 6V battery as the sole power source. If you have a 12V motor, you can of course use a 12V power source.

The motor is switched on and off via a TIP31C transistor (shown in figure 3) which can handle motors rated up to 3A at 100V, or a total power of 40W. If you are using a high power motor, make sure there is a heatsink bolted to the transistor.

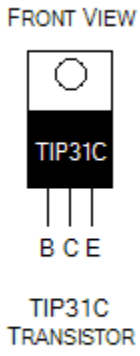


Figure 3: Pin-out diagram of the TIP31C transistor

Calibrating the Circuit

The nature of this circuit means that the motor can never be fully switched off. However, the minimum 0.3% duty cycle should be low enough to effectively stop the motor running.

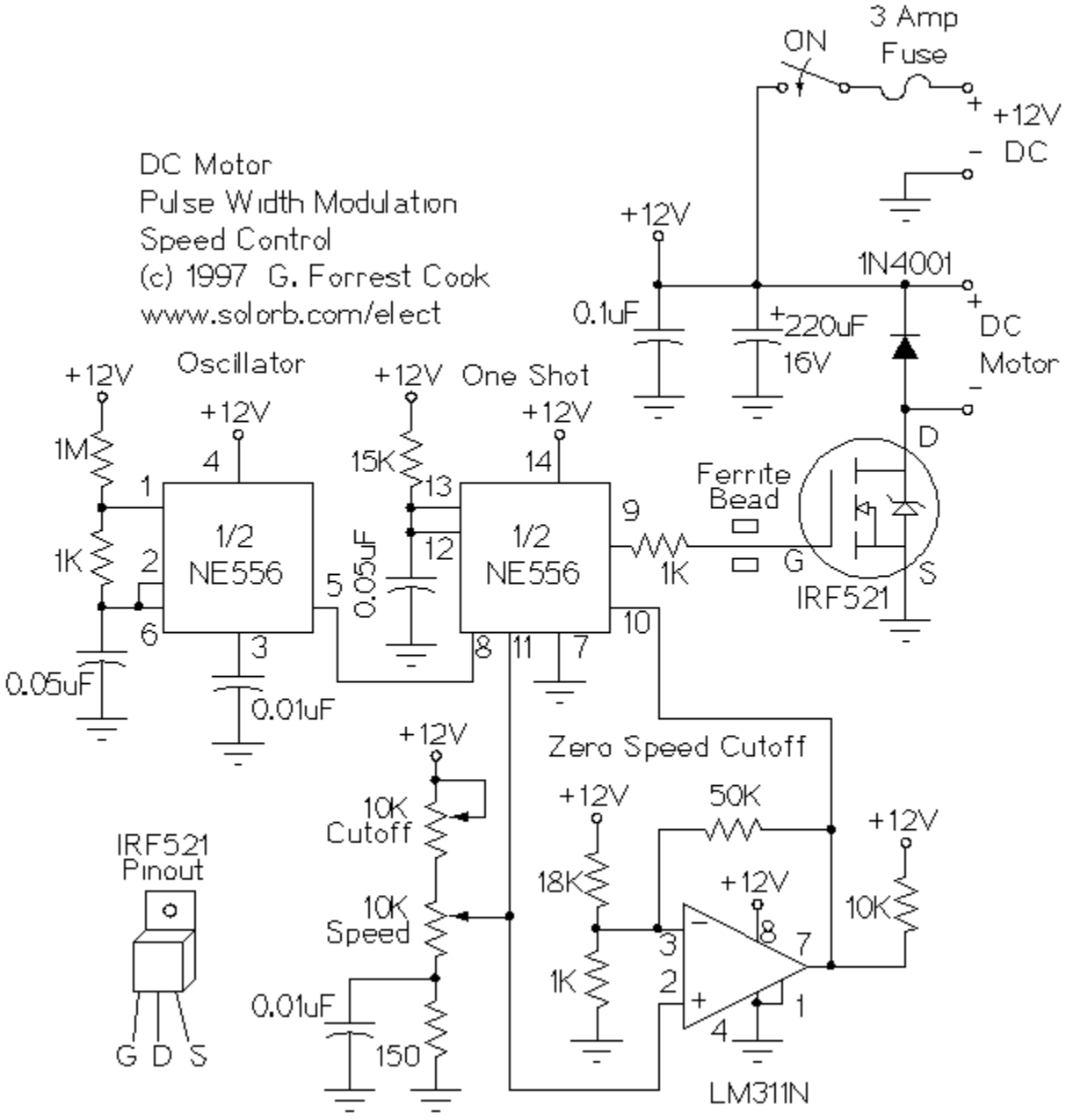
When you first switch the circuit on and move the speed potentiometer slowly from its minimum position to its maximum position, you will probably find that the speed of the motor increases linearly, then suddenly drops slightly before increasing again. This is

due to the **pulse width** becoming longer than the time allowed for it by the 555 astable.

The frequency preset of the 555 astable circuit solves this problem by allowing the frequency of the signal to be adjusted so that the speed potentiometer can achieve its full range. To calibrate it, set the speed potentiometer to its maximum position, then adjust the frequency preset so that the motor runs as fast as possible. If you have a multimeter that can measure frequency, you can check the modulation frequency at pin 3 of the 555 astable, and confirm the range of the duty cycle at pin 3 of the monostable.

http://www.eleinmec.com/article.asp?28

Example 2 : using 556 ICs



Circuit Description

This is a circuit for controlling the speed of small DC motors, it works nicely as a speed controller for an HO or N gauge model railroad.

Theory

The left half of the 556 dual timer IC is used as a fixed frequency square wave oscillator. The oscillator signal is fed into the right half of the 556 which is configured as a variable pulse width one-shot monostable multivibrator (pulse stretcher). The output of the one-shot is a variable width square wave pulse, the pulse width is set with the speed control pot on the control voltage input. The variable width output pulse switches the IRF521 MOSFET transistor on and off. The MOSFET amplifies the current of this signal so that it is powerful enough to control a small DC motor. The 311 comparator is used to cut off the one-shot via the reset pin when the control voltage is below a certain threshold, the 311 is also controlled by the speed control pot.

The cut off circuit is necessary because the 556 one-shot circuit will always put out a small pulse, even when the control voltage is at zero.

Calibration

Adjust the 10K cutoff pot so that the motor is completely off when the speed pot is fully counter clockwise.

http://solorb.com/elect/pwm/pwm0/

Example 3 :Pulse Width Modulator for 12 and 24 Volt applications

This circuit was featured in an article in Home Power Magazine #75
(C) G. Forrest Cook 1999

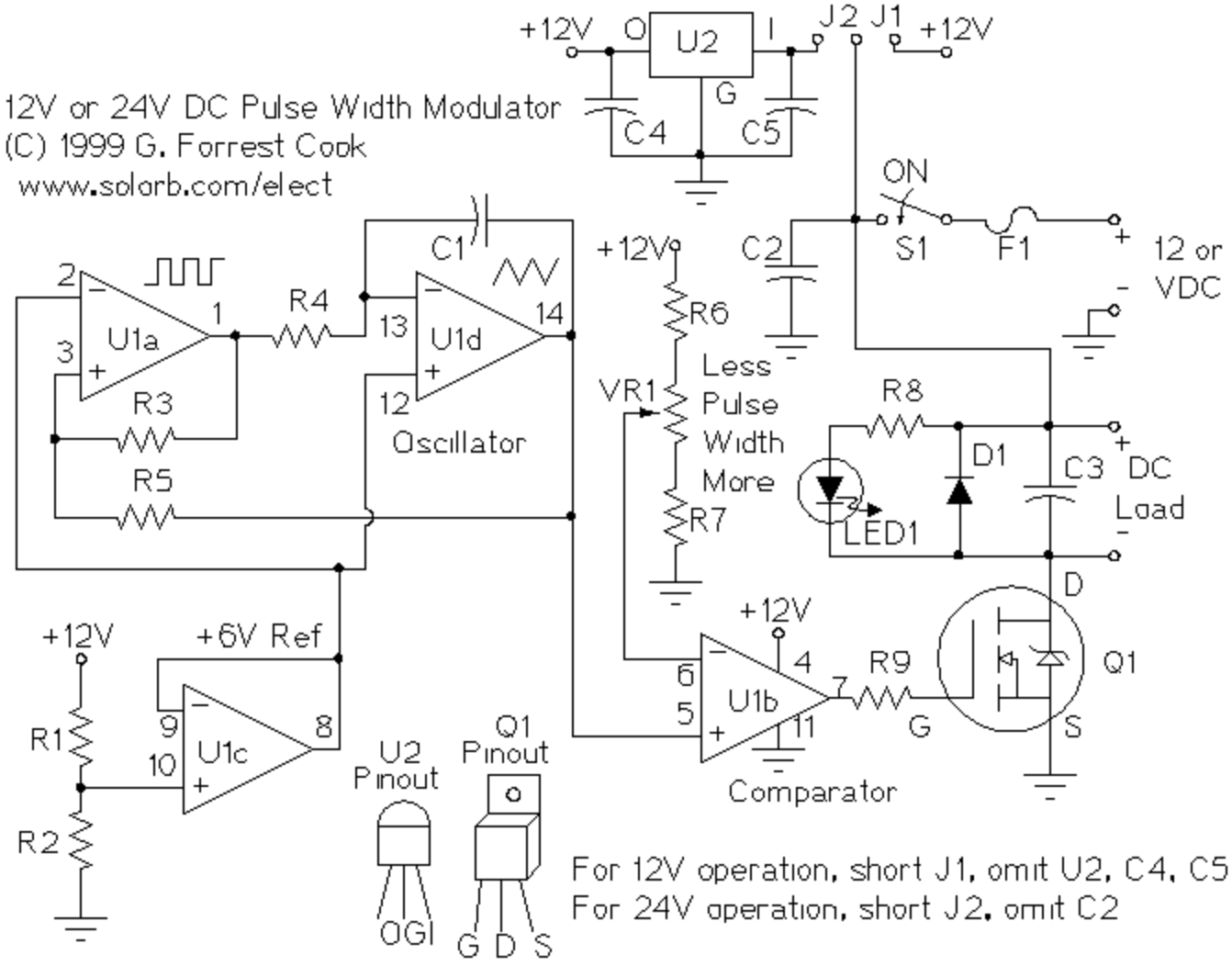
Introduction

A pulse width modulator (PWM) is a device that may be used as an efficient light dimmer or DC motor speed controller. The circuit described here is for a general purpose device that can control DC devices which draw up to a few amps of current. The circuit may be used in either 12 or 24 Volt systems with only a few minor wiring changes. This device has been used to control the brightness of an automotive tail lamp and as a motor speed control for small DC fans of the type used in computer power supplies.

A PWM circuit works by making a square wave with a variable on-to-off ratio, the average on time may be varied from 0 to 100 percent. In this manner, a variable amount of power is transferred to the load. The main advantage of a PWM circuit over a resistive power controller is the efficiency, at a 50% level, the PWM will use about 50% of full power, almost all of which is transferred to the load, a resistive controller at 50% load power would consume about 71% of full power, 50% of the power goes to the load and the other 21% is wasted heating the series resistor. Load efficiency is almost always a critical factor in solar powered and other alternative energy systems.

One additional advantage of pulse width modulation is that the pulses reach the full supply voltage and will produce more torque in a motor by being able to overcome the internal motor resistances more easily. Finally, in a PWM circuit, common small potentiometers may be used to control a wide variety of loads whereas large and expensive high power variable resistors are needed for resistive controllers.

The main Disadvantages of PWM circuits are the added complexity and the possibility of generating radio frequency interference (RFI). RFI may be minimized by locating the controller near the load, using short leads, and in some cases, using additional filtering on the power supply leads. This circuit has some RFI bypassing and produced minimal interference with an AM radio that was located under a foot away. If additional filtering is needed, a car radio line choke may be placed in series with the DC power input, be sure not to exceed the current rating of the choke. The majority of the RFI will come from the high current path involving the power source, the load, and the switching FET, Q1.



http://solorb.com/elect/pwm/pwm1/

- Places to buy

1. http://search.globalspec.com/productfinder/findproducts?query=electrical%20components&se=gt%20
2. http://www.automation4less.com/?src=overture
3. http://www.usdirectory.com/nypr.aspx?afid=1937&cc=3359990000&utm_source=yahoo&utm_medium=cpc&OVRAW=electrical%20components&OVKEY=electrical%20component&OVMTC=standard&OVADID=4056496013&OVKWID=40224868513

- Wiring

        - Type and gauge
        - Connection strategies (solder, crimp)
    - Test Power Supplies (ie a supply that is used when not in the vehicle)

To power the booster use electrical hardware capable of handling 20amps DC. Run the power through the ignition circuit, so that it only runs when the vehicle is
ON. A 30 amp relay should be used to prevent damaging the ignition circuit which may not be designed for an extra 20amp draw. Make sure to use a properly rated fuse, 30amps is ideal. You can use a toggle switch for further control.

http://aquauto.com/sites/default/files/users/Nick_Stone/Chapter10.pdf

PWM3E PC board, as it comes from pcbexpress. These boards need to be painted right away to prevent oxidation of the traces (as can be seen in lower right corner of this board),
and to protect the traces from corrosion damage. Only use Testors 1601 Transparent Candy Emerald Green for this. Other types of paint may contain conductive additives that can affect operation of the circuit.

http://hydrogengarage.com/pwm3f/Boyce%20Electrolyzer%20Project.pdf

Hardware Components

- Containers (pros and cons of each)

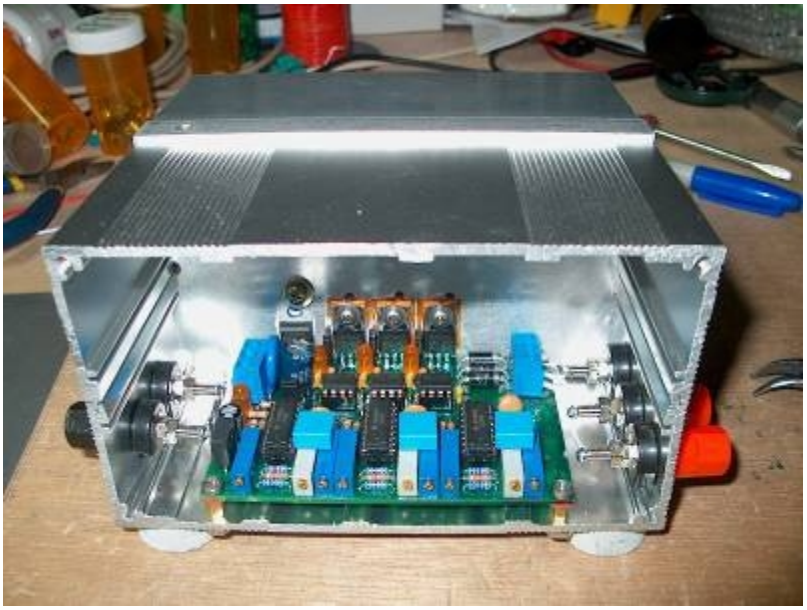
1. *Concentrator Photovoltaics (CPV):* This part consists of a small photovoltaic (PV) panel placed just outside of the focal point of a concave dish.

2. *Spectral Splitter:* Placed in front of the PV panel is a filter that is used to reflect infrared energy while allowing visible light to pass through to the PV panel.

3. *Light Pipe:* This device transfers infrared energy from the spectral splitter to the SOEC.

4. *Solid Oxide Electrolyzer Cell (SOEC) Stack:* This component of the system combines the heat from the light pipe and the electricity from the PV panel to separate water into oxygen and hydrogen molecules.

http://www.nrel.gov/docs/fy05osti/37093.pdf



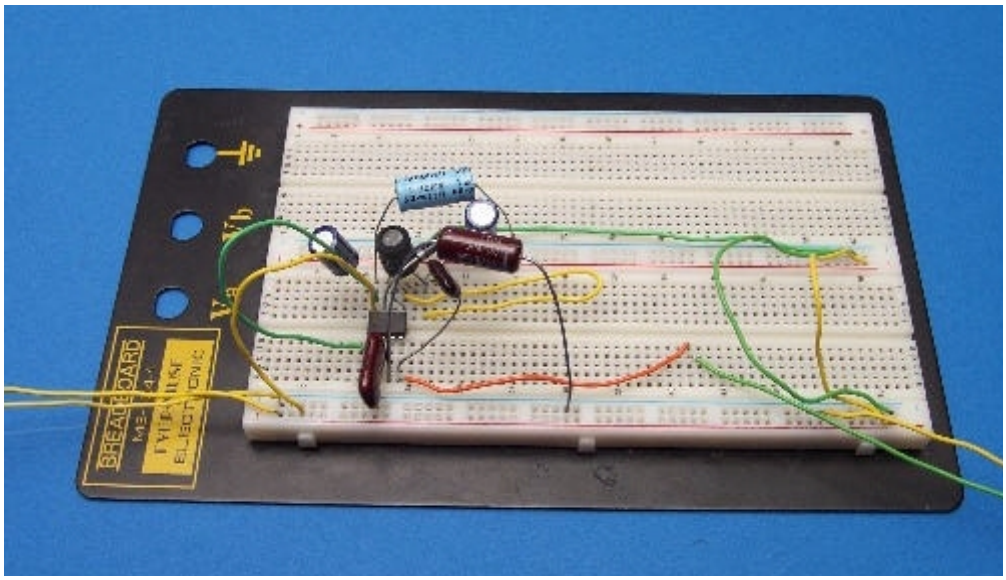
Circuit board fully loaded and housed in aluminum housing to protect the circuitry during resonance operation

http://peswiki.com/index.php/OS:Bob_Boyce_Electrolyzer:Hathaway_Photos

Note: The link below contains relevant information but since it's a protected document I cannot copy any information. But it could be good as additional reading material.

http://hydrogengarage.com/pwm3f/Boyce%20Electrolyzer%20Project.pdf

The hardware device consists of four major sections: the power conditioning circuit, the feedback device, the sensors and their connections, and the PIC microcontroller. The power conditioning circuit regulates the amount of power that gets into the controller. It is necessary because it ensures that the battery will not send too much power into our controller and fry our integrated circuits. The feed back device is made up of four light emitting diodes (LEDs), an LED driver, and the connecting wires. The feedback device will alert the user should some error occur, or it will show that the electrolysis cell is working properly when no errors occur. The sensors exist to alert the PIC to adverse conditions either in the electrolysis cell or in its connections to the vehicle's engine. The PIC determines whether or not the electrolysis cell will operate based on information from the sensors, and displays its choices to the user via the feedback device. The power conditioning circuit consists of a voltage regulating chip and a various capacitors, inductors, and resistors connected to its pins. The power conditioning circuit we used for our device is shown in figure 3.5. These extra components allow the voltage regulator to operate in its expected and most optimal conditions. The power conditioning circuit is located on the printed circuit board. It does convert the approximately twelve volts of direct current that we receive from the battery into the expected input voltage for our microcontroller, five volts DC



Power Conditioning Circuit. The chip that controls the circuit is in the center. Other capacitors and inductors are shown that bias the chip in the proper manner.

The feedback device consists mainly of LEDs and an LED driver. The LED driver is necessary to ensure that each LED receives enough current to ensure that a user will be able to clearly determine the LED as being in the on state. The correct functioning light is blue which makes it easily distinguishable from the sensor error lights, which are all red. The feedback device is located on the printed circuit board. The LEDs will be seen as bright lights in the packaged version of the final product.
The sensor portion of the controller is made up of three sensors: the vacuum sensor, the water level sensor, and the temperature sensor. Each of these sensors has the power to halt the operation of the electrolysis cell. They are given their power by the PIC microcontroller. The software programming of the PIC will halt and shut off power to the electrodes of the electrolysis cell if any of the sensors indicate that a malfunction is occurring.

http://www.ece.msstate.edu/courses/design/ece4542/2003_spring/fuel_cell/docs/requirements_prod.pdf

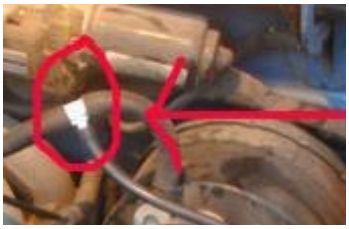
- Pvc pipe
- Acrylic pipe
- Acrylic box
- Glass Jar
- Places to buy (no pros and cons needed)

The electrolysis cell consists of a tube of 4 inch diameter schedule 40 PVC pipe that is closed at one end, the electrode end, and accessible via a screw-on cap at the other end, the hose end. Schedule 40 PVC pipe was chosen because of its convenience. It is relatively cheap for the amount of customization that may be done to it. Also all of the tools that were at hand were enough to full fill our creation needs. The electrolysis cell, during normal operation, is placed perpendicular to the ground plane in a manner with the hose end toward the hood of the host vehicle, and mounted in the bed or trunk of the host vehicle. The electrode end is facing the ground plane in this description. During normal
operation, the electrolysis cell contains 500 ml of salt-water solution. Because of the manner in which the electrolysis cell is situated, the salt-water solution is nearest the electrode end of the electrolysis cell. The electrolysis cell is not only filled with 500 ml of solution inside and also about 25 ml of air fills empty space.

If the cell is not perpendicular to the ground plane then the
saline solution has a high probability of splashing into the air intake of the host vehicle.

During the course of operation, the electrolysis cell will break down the water in the saltwater solution to such an extent that the solution will dry up. To avoid this happening, the electrolysis cell is connected to a pump that will pump in water from an external reservoir. The reservoir is a plastic container that holds approximately two liters of
water. The water must be distilled water. If normal tap water from a faucet is used any number of problems could result. Some of these problems include, excess residue in the electrolysis cell, unwanted gasses in the combustion chamber, and increased corrosion of the electrodes. During the electrolysis process only the hydrogen and oxygen gasses will be used from the water leaving any residue behind to be cleaned by the owner or a service technician. When the electrolysis cell runs low on water, our controller sends a signal to the pump to pump more water into the electrolysis cell. The water pump is connected to the electrolysis cell through a hose that is used to transfer the water.

The electrolysis cell receives water from a reservoir whenever the controller detects that the amount of water is too low. To detect the level of the water the controller uses the water level sensor. The water level sensor is made of a float that is connected to a rod that is placed at an angle orthogonal to the salt water. The rod extends into the salt water but the float will stay at the level of the water. Above the float is a magnet that triggers a Hall Effect switch. When the salt-water amount depletes after some amount of use, then the water level will be detected, as too low so the PIC will send a signal to the reservoir to refill the electrolysis cell.



Hose Connections This picture shows a hose connector that connects the output of the electrolysis cell to the air intake of the host vehicle.

http://www.ece.msstate.edu/courses/design/ece4542/2003_spring/fuel_cell/docs/requirements_prod.pdf

- Different electrode arrangements (pro's and cons of each)
  - rectangle plates
  - round disks (like washers)
  - wire
  - Places to buy (no pros and cons needed)

The very best electrode metal is made from 16 gauge 316L-grade stainless steel and is recommended that there be between 2 and 4 square inches of plate area on every face of every electrode for each amp of current passing through the cell.

Some people place an ultrasonic transducer underneath the plates to vibrate the bubbles off the plate surface. Some people use piezo crystal attached to the plates to vibrate the plates and shake the bubbles free, others use magnetic field s , usually from permanent magnets. The best method is to treat the electrodes plates with cross-hatch sourcing, an extensive cleansing processes and an extensive conditioning process. After the process, a catalyst layer builds up on the electrodes, doubling their efficiency and bubbles no longer stick to the electrodes but break away immediately without the need for any form of additional help.

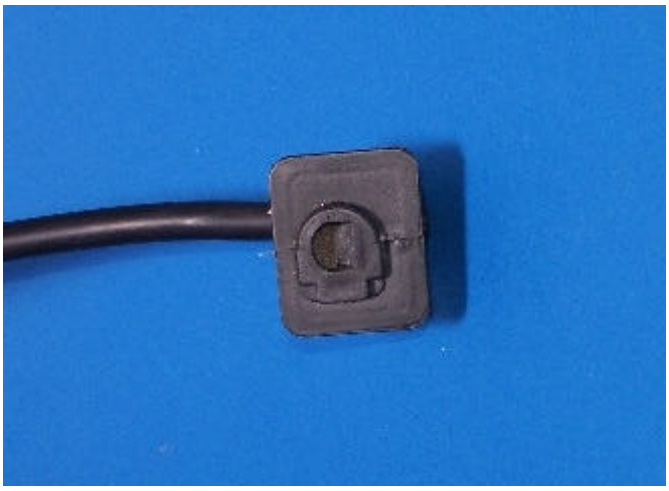
http://aquauto.com/sites/default/files/users/Nick_Stone/Chapter10.pdf

- Hardware
  - Bolts and nuts (sizes and material type)
  - Tubing (sizes and types)
  - Check valves (one way valves).

Components used

Part	Quantity	Comment
4-inch diameter PVC pipe 12-inches long	1	Forms the body of the booster
4-inch diameter PVC pipe end-cap	1	Closes the bottom of the booster
4-inch diameter PVC pipe screw cap	1	The top of the booster
90-degree Quick Connect Outlet fitting	1	3/8" O.D. Tube x 1/4" NPT from Hardware store
Level indicator Nylon barbed tube fitting	2	1/4" Tube x 1/8" NPT Part Number 2974K153 or from your local hardware store
Quarter-inch I.D. Poly sight tube	8"	Water-level indicator tubing - Hardware store
Stainless steel switch covers	16	The plate array components
Stainless steel straps 12-inches long	2	The electrical connections to the plates
3/4" Inside Diameter Clear poly tube	12-inch	From your local hardware store
5/16" stainless steel bolts 1.25" long	2	Electrical strap connection to the top cap
5/16" stainless steel nuts & washers	6 each	To fit the steel bolts in the cap
5/16" diameter nylon threaded rod	8" min.	Nylon Threaded Rod 5/16"-18 Thread. McMaster Carr Part No 98831a030
5/16" inch nylon washers 1.6 mm thick	1-pack	Nylon 6/6 Flat Washer 5/16", Pack of 100 McMaster Carr Part No 90295a160
5/16"-18 s/s jam nuts (7/32" thick)	20	McMaster Carr Part No 91841A030
90 degree Bubbler Fittings	2	1/4" Barbed Tube 1/2" NPT. McMaster Carr Part No 2974K156
Check valve	1	1/4" tube, McMaster Carr Part No 47245K27 or from your local Hardware store
PVC glue	1 tube	Same color as the PVC pipe if possible
5/16" Neoprene sealing washer	2	McMaster Carr Part No 94709A318 or from your local Hardware store
Tool dip – 14.5 oz	1	McMaster Carr Part No 9560t71
Optional: Light Emitting Diode	1	10 mm diameter, red, with panel-mounting clip
Quarter-watt resistor	1	470 ohm (code bands: Yellow, Purple, Brown)

http://aquauto.com/sites/default/files/users/Nick_Stone/Chapter10.pdf



The air coming into the electrolysis cell from outside of the host vehicle must be filtered to avoid any unwanted trash entering the combustion chamber of the host vehicle. If trash were to enter the combustion chamber any number of problems could occur that would eventually lead to the purchase of a new vehicle. Also we do not want any trash from the outside air to interfere with our electrolysis process. To filter the incoming air we used an air filter The filter is connected to a hose, which is in turn connected to the electrolysis cell. The filter that is used has a one-way valve so that the outside air may only come into the system but not out of the system. This oneway valve ensures that the hydrogen and oxygen that is generated from the electrolysis cell is only sent into the combustion chamber of the vehicle and not into the engine where any spark might set off a small combustion under the hood of the vehicle.

http://www.ece.msstate.edu/courses/design/ece4542/2003_spring/fuel_cell/docs/requirements_prod.pdf

- Glues (pros and cons)
  - Epoxy's

In chemistry, **epoxy** or **polyepoxide** is a thermosetting epoxide polymer that cures (polymerizes and crosslinks) when mixed with a catalyzing agent or "hardener". Most common epoxy resins are produced from a reaction between epichlorohydrin and bisphenol-A.

http://en.wikipedia.org/wiki/Epoxy

Epoxy Glue

A two-part resin/hardener glue that is extremely strong. It is generally available in 6 and 30-minute formulas.

Uses:

Plastic to plastic/wood, metal to metal/wood.

Pros:

Strong - note that longer setting time epoxy is often stronger and more durable.

Cons:

Difficult to sand - be careful if using it where it will need sanding to get a finish.

http://www.diracdelta.co.uk/science/source/e/p/epoxy%20glue/source.html

  - Silicon

- Goop

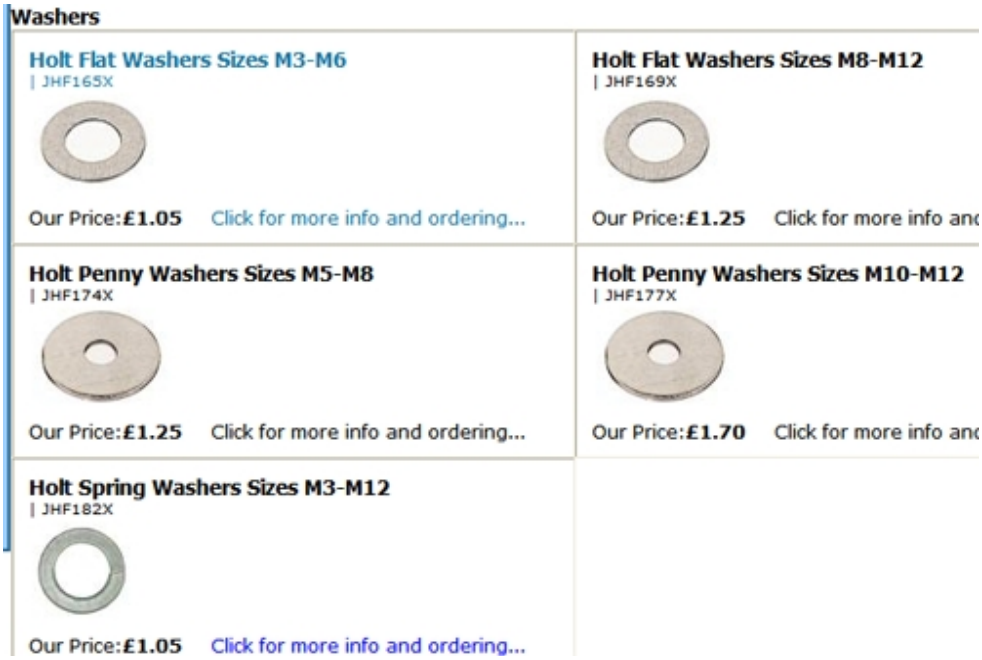
Repair cars, trucks, motorcycles and more. Bonds to metal, glass, plastic, vinyl, and leather. Seals convertible tops. Fixes seats, mats, lights, mirrors, handles, trim. Withstands heat up to 150° F. Many uses: attach loose auto trim and emblems; repair and attach cracked hoses; mend leather

http://goshopping.thestar.com/shop/product--catId_1002488__locale_en__productId_3143200.html

Pros
It works under the most adverse conditions; it *sticks to virtually everything and remains flexible*!

Cons:
GOOP cannot be used in place of latex or silicone caulks where appearance is critical.
http://www.naturalhandyman.com/iip/infadh/infgoo.html

- Washers (sizes and types)



http://marinestore.co.uk/Merchant2/merchant.mvc?Screen=CTGY&Category_Code=washers-stainless

  - Places to buy
- Electrolytes (pro's and con's of each
  - NaOH
  - KOH
  - Baking Soda
  - Etc

If the liquid of the electrolyzer is distilled water, then almost no current will flow and almost no gas will be produced. If you add two or three drops of battery acid to the water, the current and gas production increases enormously. Putting acid in the water is a bad idea as it gets used in the process, the acidity of the water keeps changing, the current keeps changing, the acid attacks the electrode the unwanted gases are given off. Putting

salt in the water, or using seawater, has nearly the same effect with poisonous chlorine gas being given off. Baking soda is alsoa bad choice as it gives off carbon monoxide which is a seriously toxic gas, it damages the electrodes and ends up as sodium hydroxide. Instead of using these activities, it is much better to use a "catalyst" which promotes the electrolysis without actually taking part in the chemical process. The best of these are sodium hydroxide (Red devil lye in USA, "caustic soda" in the UK) and even better still, Potassium hydroxide ("Caustic Potash").

http://aquauto.com/sites/default/files/users/Nick_Stone/Chapter10.pdf

Different Known Electrolyzers

- Electrolyzer designs (pro's and con's of each as well as the 'setups' used in by the creator. By 'setups' I mean: electrode spacing, electrolyte type, amps, volts, etc.…)
    - **H2O Hybrid Pro** (***http://www.h2ohybridpro.com***) - Internal combustion retrofit hydrogen generator kits for both diesel and gasoline engines. Make any vehicle a hybrid.

    - **Hydrogen-Boost Mileage Enhancement System** (***http://www.pureenergysystems.com/store/Hydrogen-Boost/***) - On-board electrolysis system injects hydrogen into air intake, to improve mileage and power, while decreasing emissions. Other enhancements also included in package deal, which includes a ScanGauge II (*http://www.pureenergysystems.com/store/ScanGauge/*).

    - **Smack Booster hydroxy injector** - Another on-board electrolysis system provides hydroxy gas at a rate of 100 liters per hour, to go into the air intake, which is said to improve mileage and decrease emissions. The Smack booster plans are available for free, and it costs very little to build yourself. Also, a kit is available for $200.

    - **HAFC: Hydro Assist Fuel Cell kit** - The HAFC kit presently for sale combines three fuel saving technologies along with a sophisticated computerized emission system optimizer. It includes 1) an electrolysis unit for on-board hydrogen injection; 2) a vaporizer/ionizer using magnets; and 3) additives that include acetone and xylene.
        - **JeffOtto.com LTD's challenge to HAFC critics** - HAFC hydrogen boost dealer, Jeff Otto, lays down the gauntlet regarding the company (UCS of A)'s guarantee of a 50% improvement in mileage, asking for any skeptic to come forward with $5000 cash to matched by him in the same amount. Winner takes all. (*PESWiki*; March 28, 2008)

    - **Independent Report on Water4Gas** - Ebook by Ozzy Freedom provides instructions on how to build an on-board electrolizer to provide hydroxy gas to inject into the air intake of a vehicle for improved mileage and performance, as well as reduced emissions. How does it compare to other systems, kits, plans?

(*PESWiki*; March 10, 2008)

- **Modifying the ECU to Accomodate a New Mixture from Hydrogen Boosting** - One of the most knowledgeable researchers and compilers of the various approaches being tried with on-board electrolizers is New Energy Congress member, Noah Seidman. This is his latest article on the topic. (*PESWiki*; July 2, 2008)

- http://www.hydrogen-water-cars.com - Includes MAP sensor enhancers, electrodes, 316L wire.

- **The Water/Fuel Converters Project > The Water/Fuel Converters Project Website (*http://www.waterfuelconverters.com/*)** An electrolysis initiative that sets forth to clearly establish the difference between Brown's Gas, Rhodes Gas, Oxy-Hydrogen, HHO, and the production methods thereof. (*FEN*; Dec. 2, 2006)

- **Get Hydro Power (.com)** - Next generation hydrogen boost technology announced, with present performance in range of 15% to 50% improvement in fuel economy. Latest innovation may boost that to between 50% and 100% mileage improvement.

- **Bob Boyce System Replications Reporting 40-60% mpg Increases (*http://pesn.com/2007/11/29/9500461_Boyce_Electrolyzer_replications/*)** - Another update by Michael Couch on various developments in the water fuel cell field, in which hydroxy gas from electrolyzed water is added to the air intake of a vehicle. The teamwork resembles the days of pre-Apple computer collaboration. (*PESN*; Nov. 29, 2007)

- **Mileage Results from Hydroxy Boost Addition** - Robert Pritchett reports on experimentation with a Ford E350 Cargo Van dubbed the "Hindenburg II" as he transforms it from an ugly duckling fuel liability to a smooth-gliding fuel-efficient goose. (*PESWiki*; May 23, 2008)

- **Hydrogen Technology Applications Inc** - HyTech (nickname for Hydrogen Technology Applications Inc) claims a process of converting H20 to HHO, producing a gas that combines the atomic power of hydrogen with the chemical stability of water. Tightly related to Brown's Gas (*http://www.freeenergynews.com/Directory/RhodesGas*) technology.

- **Hydrogen-Boost (*http://www.hydrogen-boost.com/index.html*)** System is a gas mileage enhancement system (*http://www.hydrogen-boost.com/november2001.html*) that includes an on-board hydrogen gas generator, fuel heater, fuel vaporizor, fuel/air mixture adjustment, engine lubricants and driving tips.

- **HydroStar Electrolysis Conversion Kit** - Plans being sold for installing what is essentially a Brown's gas unit on car, to run H/O mixture into air intake, enhancing fuel combustion for mileage enhancement. Questionable dealer site claims and wording, data lacking.

- **Oxy Hydrogen** (***http://savefuel.ca/oxy-hydrogen/***) - Add-on unit increases fuel economy by an average of 15 - 28 %.

- **Hotsabi's e-Cell is a Joe Cell variant** - Uses an electrolysis process to inject hydrogen into the air intake of a vehicle, resulting in improved fuel economy of around 50%.

- **HyZor** (***http://www.eagle-research.com/fuelsav/hyztechld.html***) by Eagle-Research replaces some fuel with water.

- **HyPower Fuel** (***http://www.hypowerfuel.com/***) - The design of the HyPower Pak® makes it easily installed on any internal combustion engine, regardless of the fuel source. It is a closed chamber unit that produces hydrogen and oxygen on demand.

- **H2 N-Gen** (***http://ihsresearch.com/***) by Innovative Hydrogen Solutions.
    - **IHS Preparing After-Market Hydrogen Supplement Device for Vehicles** (***http://pesn.com/2005/11/25/9600207_Innovative_Hydrogen_Solutions_Inc/***) - Innovative Hydrogen Solutions, Inc. of Canada has been developing an electrolysis unit that extracts hydrogen and oxygen from water and adds it into the air intake of a vehicle, to increase fuel economy by anywhere between 10% and 30%. (*PESN*; Nov. 25, 2005)

- **Hydro-Gen™** (***http://www.savefuel.ca/***) users report an average 21% improvement in their gas mileage.
- **Hydrogen Innovations** (***http://www.burnh2o.com/***) - The HydroGen system provides a cleaner, leaner burn, which gives you a 15% to 40% increase in fuel efficiency.

- **Canadian Hydrogen Energy Company** (***http://www.chechfi.com/***) - CHEC HFI hydrogen injection system for large diesel engines.

- **Hy-Drive Technologies** (***http://www.hy-drive.com/***) - Claims a significantly more efficient electrolysis process.

- **Liberty Hydrogen** (***http://www.energistx.com/energy/libertybooster.html***) H2O Hybrid Mileage Booster.

- **waterpoweredcar.com** (***http://waterpoweredcar.com/hydrobooster2.html***) - How to make a Hydrogen Booster Yourself
- **Hydrogen Car & Multi Fuel DVD** (***http://www.knowledgepublications.com/hydrogen_car_dvd/h2_car_dvd.htm***) teaches how to hydrogen-boost your engine.
- **BingoFuel Reactor** (***http://jlnlabs.imars.com/bingofuel/html/bfrhowto.htm***) is an underwater carbon arc. It produces COH2 gas that can burn very cleanly in air as

fuel for an internal combustion engine. May be higher efficiency electrolysis. The Carbon Arc looks very promising as providing excess energy (*http://www.intalek.com/Index/Projects/SparkGapExp/SparkGapExp.htm*)

- **H To Go (*http://www.htogo.com/*)** - MAPSOE electrolysis units produce Hydrogen from water on board a vehicle, enhancing the fuel economy of gasoline, diesel or bio-diesel internal combustion engines and minimizing emission levels. Test data shows up to 73% more mpg with the hydrogen unit. Distributed in New Zealand by Vision Energy (*http://www.visionenergy.co.nz/*). See also Hydro-charger (*http://www.fuelcellsworks.com/Supppage6480.html*)

- **Hydrogen Water Car HHO Store (*http://www.hhokitstore.com/*)** (Direct Retailer) is one of the only retailers of on board vehicle hybrid fuel systems which carries more than one brand of kits. Above Technology coined the term **electrolytic injection** to describe the products in order to give some consistency to the terms used by the industry. Above Technology carries pre-built kits and supplies from reputable manufacturers.

- **Go Green Fuel Systems - Hydrogen Enrichment Technology (*http://www.gogreenfuel.com/*)** - Go Green 2448 is an on-board, on-demand, hydrogen enrichment system that will increase mileage typically from between 10% - 20%, sometimes more, and decrease emissions, especially Carbon Monoxide and NOx. Installation is quick and easy.
    - **Not-Tsoo-Pa Enviro Fuel Systems (*http://www.ntpefs.com/*)** - Northwest Distributor of the Go Green Fuel System
    - **Water Visions (*http://www.hydrofuel2005.com/*)** - HydroFuel Go Green Fuel Economy System™

- **HydroGen Automotive Parahydrogen Generator (*http://cgi.ebay.com/Hydrogen-Generator-Save-Fuel-Gas_W0QQitemZ5846858996QQcategoryZ294QQssPageNameZWDVWQQrdZ1QQcmdZViewItem*)** requires no electrolyte.
- **The hydro boost device you can build yourself (*http://www.angelfire.com/ak5/energy21/hydroboost.htm*)**
- **Dynamic Fuel Systems (*http://www.dynamicfuel.com/*)** - The Jetstar™ is a transportable hydrogen generator retrofit targeted for use in the heavy tractor trailer industry.
- **Energy Enhancement Technologies (*http://www.energyenhancement.ca/*)** has developed a plate device, using Nanotechnology that enables it to produce significantly more Hydrogen and Oxygen while not having to use dangerous, caustic solutions.

- **HydroGator (*http://www.hydrogator.com/page/page/3567720.htm*)** - Hydrogen fuel saver add-on supplement provides 12->35% average (highway up to >50%) fuel savings.
- **HydroCharger (*http://www.hydrocharger.net/*)** - A bolt-on hydrogen fuel generator module (size 12x12x12") that can be placed in a car trunk, truck bed, back of SUV or even mounted in engine compartment if desired. Designed to passively utilize your computerized fuel manangement system to increase gas mileage, clean engine.

- **Hydro Assist Fuel Cell (*http://www.gasally.com/hafc.htm*)** - The HAFC (*http://befreetech.com/save_gas.htm*) is a combination of several technologies. One of these technologies is a unit that extracts a Hydrogen-Oxygen mixture from distilled water. The HAFC adds extra hydrogen to the fuel mixture, which burns easily and powerfully and enriches your fuel mixture, giving you added mileage and power. The added oxygen also increases the octane level of your fuel. A Dennis Lee product.

- **MileageMaker** (***http://www.mileagemaker.us/***) - Our electrolyzing hydrogen and oxygen generator splits the gases in H2O (water) through the input of excess electrical output from your alternator. This excess electrical output is generated by your alternator whether you use it or not. Our MileageMaker generator simply allows you to stop wasting the excess energy and uses the energy to split the electrolyte into combustible gases.

- **Green Future Technology** (***http://www.greenfuturetechnology.com/***) - The GFT Hydrogen Generator® turns any internal combustion engine into a virtual hydrogen-hybrid. It burns tap water only, not distilled water mixed with electrolytes, giving 20% to 40% better mileage.

- **Hydraficient** (***http://www.hydraficient.com/drupal/***) - This multi-electrode array design offers higher Hydrogen production than any other device on the market while requiring no electrolyte, maintaining low power requirements, operating at lower heat production, and maintaining the lowest cost per liter of production available.

- http://www.savefuel.ca/hydrogen/ebook.php?id=ebook

- **Diesel Hydrogen Injection** (***http://www.dieselhydrogeninjection.com***) System designed for heavy-duty diesels

http://peswiki.com/index.php/Directory:Fuel_Efficiency_Hydrogen_Injection

What are the optimized arrangements?

To understand how an optimized Electrolyzer works, typically requires a working knowledge of several disciplines: Electronics, Electrical Engineering, Chemistry, Physics, And Mechanical Engineering. Electrolyzers make hydrogen by passing an electric current through water containing an electrolyte. The Electrolyzer has the potential to lower the cost of producing hydrogen energy through the water electrolysis process. For example, General Electric researchers have built and tested an Electrolyzer big enough to make a kilogram of hydrogen per hour. Within the next five to ten years, Electrolyzers could serve as the foundation for future hydrogen vehicle refueling stations. The key however, is an optimized Electrolyzer, which splits out the hydrogen in a way that doesn't require massive amounts of electrical current.

So then how much HHO can typical water for gas Electrolyzer's produce? It's low. Maybe 1.5 liters. I have discovered however, that it's not the huge amount of HHO, but a clever implementation of the system. The small Hydrogen atoms ram onto the gas particles making them smaller and thus more efficient in the combustion process. Of coarse HHO or Hydroxy itself very flammable and will also aid in improving your fuel economy. But the important thing to consider is the interaction of the HHO and the gasoline mist that is in the combustion chamber. It is like putting a needle to a balloon. It only takes a trigger, not a brutal force, to enhance the performance of gasoline.

http://www.articlesbase.com/automotive-articles/how-much-hho-or-hydroxy-does-the-electrolyzer-produce-494416.html

- best electrode spacing

In general, the closer together the better, but according to Bob Boyce's extensive experience this is the minimum possible before free hydroxy bubble dislodgment becomes impeded.

Keeping in mind that Bob's unit produces a LOT of hydrogen, way more than a brute force sealed series, I can understand the need for a 3mm distance between plates. However in a brute force unit does this still hold true? There are lots of postings suggesting a 1.5mm spacing instead.

The spacing is at 1/8" because if it is closer the bubbles would have a hard time getting out of the space think of it as grapes and pingpong balls they need space to get out and if the space is too close a traffic jam happens

http://tech.groups.yahoo.com/group/Hydroxy/message/22543

- best electrode sizes
- best electrolyte (
- most amps per square inch of electrode
- etc…

The square form of permeable electrode is advocated for use in pressure electrolysis process units for high, uniform hydrogen and oxygen gas yields per unit area of exposed electrode surfaces.

The square form electrode assures uniform electrical conductive flow between the narrow electrolyte gaps between each face of the square anodes and cathodes for even gas molecule polarization.

Both thin wall porous rectangular metallic sheets, or extruded square porous metal tubes can be used, or fine mesh monel screening of 400 mesh size may be the electrode material.

The total exposed electrode surface area must be as large as possible compared to the overall cell unit size and electrolyte volume.

http://www.freepatentsonline.com/3959113.html

Efficient hydrogen production is critical to fuel cell operation. One of the most convenient methods to produce hydrogen is via water electrolysis. However, overpotential losses at the cell electrodes results in poor efficiency. In this study we carried out water electrolysis experiments with ruthenium (Ru) nanorod arrays as the cathode. We show up to 25% reduction in overpotential and 20% reduction in energy consumption by use of the Ru nanorod cathode compared to the planar Ru cathode. We attribute the improvement to the increased active area of the nanostructured electrode which reduces the operating current density of the electrolyzer. ©2006 *American Institute of Physics*

http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=APPLAB000088000026263106000001&idtype=cvips&gifs=yes

- **Tools needed to build an electrolyzer**

TOOLS LIST

1. Hand drill
2. Cutters (for mesh and shimstock)
3. 1/4" NPT tap and 5/16" drill bit
4. 3/8" NPT tap and 1/2" drill bit
5. 10/32" tap and 1/8" drill bit
6. Clamp and 1" x 1" wood strip
7. Hex key "T-handle" wrench to fit capscrew
8. Philips screwdriver
9. Small adiustable wrench

http://aquauto.com/sites/default/files/users/Nick_Stone/Chapter10.pdf

Vehicles install instructions

Components and definitions

Essentially the electrolyzer is a water holding tank which is mounted inside the engine compartment under the hood of the vehicle. Electricity is added to the electrical components inside the electrolyzer which break down the water into hydrogen and oxygen gas by a unique process of magnetic enhanced electrolysis.

Hydrogen, in combination with other electrolyzed gases is introduced into the intake manifold of the engine. When these gases are drawn into the cylinder they accelerate the flame spread during combustion. This causes more of the vaporized fuel injected into the cylinder to combust during the power stroke. More fuel is combusted, and less fuel is wasted through the exhaust, thereby creating more power from the fuel which was injected into the combustion chamber. Less fuel can now be used by the engine to maintain "normal" power levels, increasing overall engine efficiency and gas mileage.

http://www.dynamonetwork.com/

The performance of a gas fuelled spark ignition engine is enhanced when relatively small amounts of hydrogen are present with methane. This improvement in performance, which is especially pronounced at operational equivalence ratios that are much leaner than the stoichiometric value, can be attributed largely to the faster and cleaner burning characteristics of hydrogen in comparison to methane. Through analytical simulation of engine performance, the addition of hydrogen is considered through its production in situ on board the engine by electrolysis of water with the necessary energy supplied from engine power. It is shown that when the work energy required for the production of hydrogen by electrolysis is taken into account, the range of viable operation of such an engine is very narrow. This would render the whole concept of in situ hydrogen production through water electrolysis uneconomical in conjunction with engine

operation, even though the presence of additional oxygen produced with the hydrogen tends, in principle, to improve engine performance beyond that observed with hydrogen addition

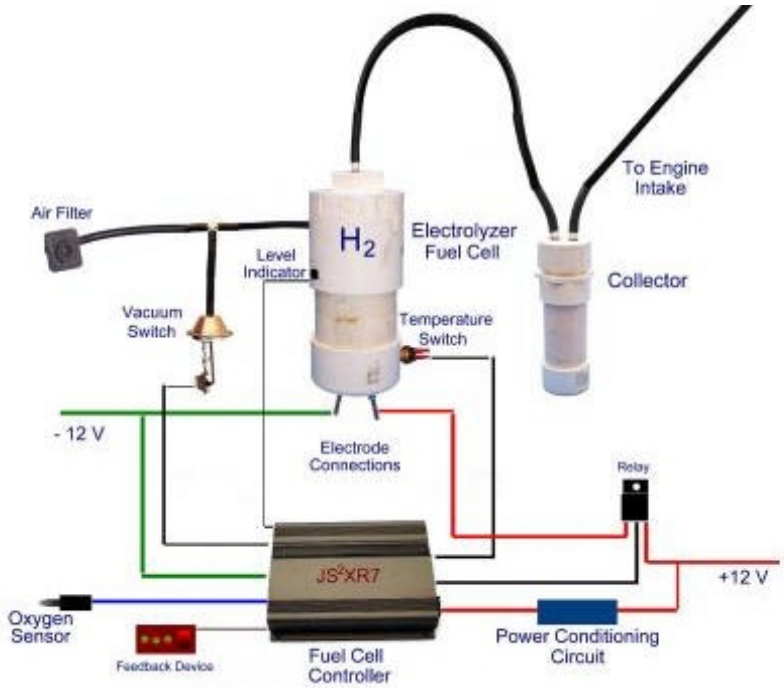
http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V3F-40BPTC6-8&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=1351dd7f0100355b58fadef2ac1f20c1

Mount the HHO device in the engine compartment. It should be mounted flat and level, and secured is such a manner as to assure that it cannot bounce around when the vehicle hits bumps etc. Position the device so that it can easily be accessed and can be conveniently removed and filled with water, or cleaned, serviced or inspected.

http://www.richlandelectronics.com/inofhhoki.html

Note: The link below contains relevant information but since it's a protected document I cannot copy any information. But it could be good as additional reading material.

http://www.free-energy-info.co.uk/D17.pdf



One method to inject hydrogen and oxygen into the combustion chamber is to create an electrolysis cell that would run current through a saline solution and then connect the resulting output to the air intake of the car. An important consideration that should not be forgotten is the oxygen sensor of the car. The oxygen sensor operates by checking the oxygen levels in the exhaust. With the previously proposed process, an excess of oxygen would be found in the exhaust. The oxygen sensor would interpret the increased amounts of oxygen as meaning that the vehicle was receiving too little gasoline and then send a

signal causing the car to use more gasoline. The result of this would be decreased fuel economy. To avoid the oxygen sensor problem we have created a controlling circuit that adjusts the output of the oxygen sensor and also measures the level of water, the temperature of the water, and the vacuum in the electrolysis cell.

circuit is mounted in the dashboard of a vehicle and powered by the DC voltage of the car's battery. A voltage regulating circuit is in place to ensure that the microcontroller receives the proper amount of voltage as well as protection from improper connection. Light emitting diodes are used to give information regarding conditions inside the electrolysis cell i.e. temperature of the water etc. A separate driver is used to drive these diodes.
To test the system the circuit was given a variety of input voltages, representing the different sensor outputs, and the responding LEDs and the output voltage of the circuit was observed. The sensors were tested individually and later they were tested as a

system.

http://www.ece.msstate.edu/courses/design/ece4542/2003_spring/fuel_cell/docs/requirements_prod.pdf

Installing the Hydrogen Boost System is a matter of installing four components on gasoline vehicles and only three on diesel vehicles. The hydrogen generator also known as the electrolyzer, the fuel heater, the engine treatment, and the electronic control circuit comprise the gasoline system. The diesel system has no electronic control circuit.

http://www.mimousa.com/hydrogen/installation.asp

- Components for attaching/wiring the electrolyzer in the vehicle
  - relay's
    relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. It was invented by Joseph Henry in 1835. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier.

    http://en.wikipedia.org/wiki/Relay
  - switches
  - wire (the appropriate gage)
  - electrolyzer bracket (hardware to attach the electrolyzer to the vehicle)

The hydrogen generator is usually installed in the engine compartment or under the front fender. It is usually placed in position where it rests on something sturdy and it is held in place with a mounting bracket that bolts to the vehicle. The wiring to the hydrogen generator is a separate circuit installed from the vehicle battery, through a fuse holder, an ammeter, and a relay, to the center electrode of the hydrogen generator, which is grounded by the mounting strap and/or a separate ground wire clamped to the outside of the unit. The relay is activated by a single wire from the fuel pump relay. The wiring kit supplies all the wire and connectors needed for installation along with the fuse holder, relay and ammeter. The wire does need to be cut to size, stripped, and terminated with various wire connectors crimped to the end of each wire.

The fuel heater is a simple heat exchanger that is installed in a convenient location and is plumbed to the cabin heater hose circuit and the fuel line coming to the injector rail. For some vehicle application the factory hosing will not reach, you may need to purchase a few feet of heater hose, fuel line and clamps to install the fuel heater.

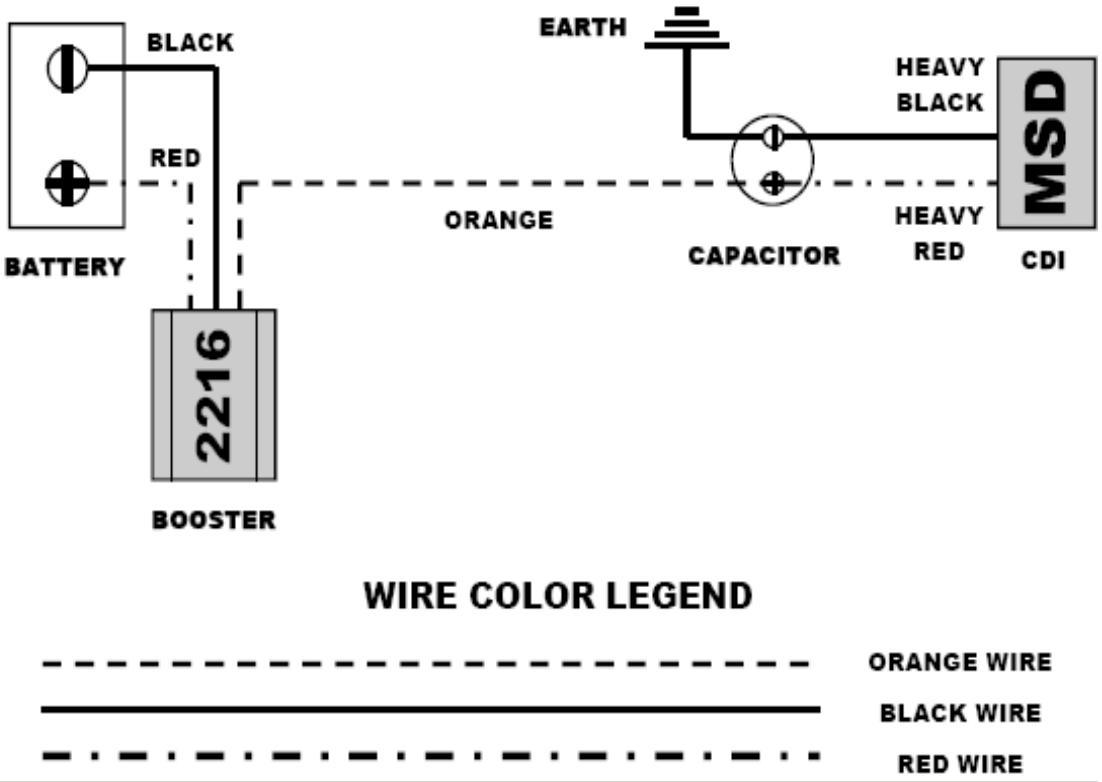
The engine treatment is simply added to the oil sump. On diesel vehicles we also include a permanent transmission treatment and a permanent differential treatment that is simply added to the lubricants in each.

The electronic control circuit is a simple potentiometer (variable resister) that is installed on a couple wires run from your cabin into the engine compartment and attached to the MAF (mass air flow) sensor signal line or MAP (manifold absolute pressure) sensor signal line. The potentiometer (dial) is installed in a convenient location where the driver can adjust the air/fuel ratio to a leaner setting than normal while driving. All wire connectors and wire are included with the system. During operation the upstream oxygen sensor is unplugged. The oxygen sensor is operational, the reason it needs to be kept unplugged because otherwise it will overwrite the adjustment of the electronic control circuit by increasing the fuel injected as it senses to extra lean air/fuel mixture. If you keep it unplugged it will not overwrite anything and the system will work smooth. If you have inspections in your state, you will have to plug the oxygen sensor back in place for the initial inspection and unplug it afterwards.

Installation can take between two hours and eight hours

http://www.mimousa.com/hydrogen/installation.asp

Wiring diagram to suite CDI (EG: MSD) ignition

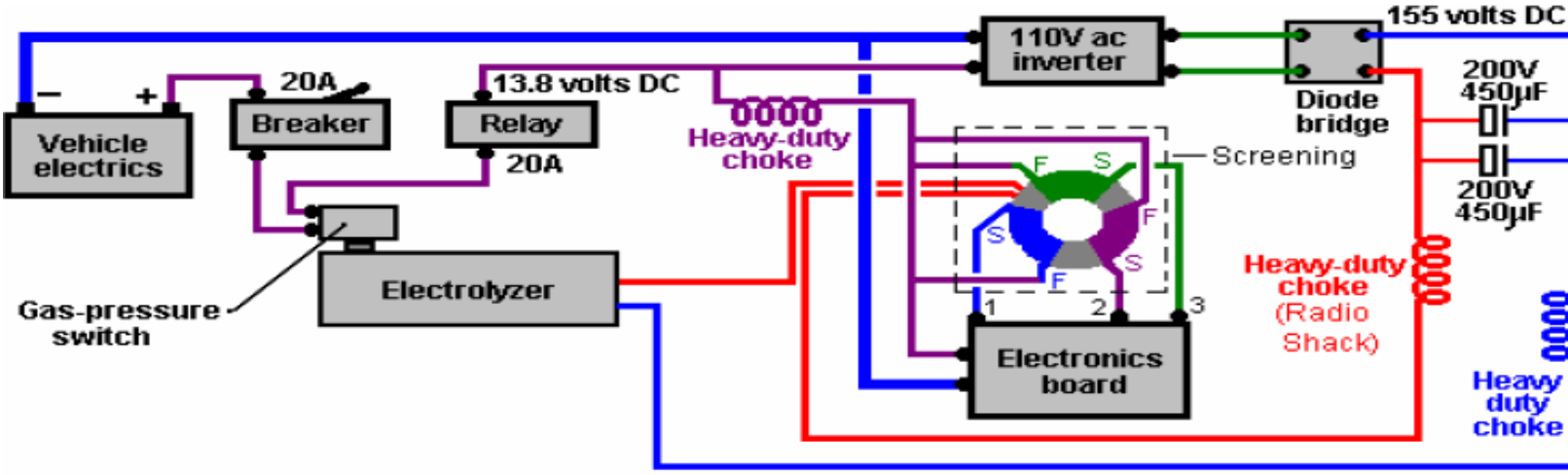


ADDITIONAL NOTES TO WRING DIAGRAM

- . Mount booster as close to battery as possible (usually at rear of vehicle).
- . Keep red and black wires as short as possible (maximum length of 18 inches).
- . Mount capacitor as close to CDI unit as possible (usually at front of vehicle).

- . Keep orange wire as short as possible for specific application.
- . Necessary wiring is provided as part of installation package.
- . Booster can only be used to power a single CDI system.
- . Suitable for MSD 6A, 6AL, 7AL-2, 10, Digital 6 and Digital 7.
- . Take care not to short posts on capacitor even when power is turned off, as capacitor stores voltage.
- . Ensure booster is fitted with supplied vibration absorbing mounts (VAMs) in a moisture free area.

http://www.iceignition.com.au/2216-CDI_WIRING_WEB.pdf



The electrical power passes through the gas pressure switch mounted through the electrolyser. If the gas production rate is grater than the engine requirement and as a result, the gas pressure inside the electrolyser gets above 5 psi. then the gas pressure switch disconnects the switch the electrical supply which in turn cuts off the generation of more gas until the pressure inside the electrolyser drops again as the engine uses the gas. If all is well the gas pressure switch will be closed and the electrical power is then passed to the relay's switch contacts. The relay is wired in such a way that the relay will be powered up if , and only the engine is running. If all is well and the relay contacts as closed, then the power is passed through to both the inverter and the electronics board. The inverter output is 110volts AC so it is passed through a diode bride which converts it to pulsing DC with peak value of about 115 volts. This voltage and the output of electronics board toroidal transformer are passed to the electrolyser to break down the water and generate hydroxy gas. The wire connecting the vehicle negative to the inverter and the electronics board should be very heavy duty. For clarity, the diagram above show the electronics circuit board below the toroid, but due to the very strong magnetic field generated by the toroidal transformer, the circuit board is physically placed in a hole in the center of the toroid as that is the one place where there is no significant magnetic field.

http://aquauto.com/sites/default/files/users/Nick_Stone/Chapter10.pdf

- Modifications for the vehicle's sensors
  - O2 sensors
    - EFIES

Depending on the year, make, model of the vehicle, it may be necessary to install a map enhancer in order to 'trick' your ecm. What happens, is the O2 sensors will read an increase in oxygen in the exhaust mix and enrich the fuel and you will lose gas mileage. If you see an initial increase then it drops back down, this is

what has happened. There are several methods that are currently being used to overcome this problem and here is the order of trial and error that I personally suggest:

1. Simply wrap the outer portion of your pre-cat o2 sensors with aluminum foil a few times and secure with small thin wire--so the foil will not blow off.

2. Use a 'stand-off' to slightly pull the O2 probe out of the exhaust stream. (This has been shown to work better than the aluminum foil in some cases)

3. Disconnect your closest O2 sensor--it will throw a code and your check engine light will come on, but if you can ignore that this MAY also work--I haven't personally tested this one as of yet.

4. Last resort, have a map enhancer or EFIE professionally installed. The object here is to slight vary the signal voltages from the O2's and/or the map/maf sensor in order to fool the ecm into thinking everything is ok so it will not enrich the fuel mix.

http://www.richlandelectronics.com/inofhhoki.html

The oxygen sensor is a device that monitors the amount
of oxygen in the exhaust of the vehicle. The oxygen sensor sends a voltage based on the amount of oxygen in the exhaust. This voltage is directly proportional to the ratio of the amount of oxygen in the exhaust to the amount of oxygen in the surrounding area. The voltage that is sent by the oxygen sensor is an amount between zero and one volt.
To test the functionality of the oxygen sensor the following is needed: the oxygen sensor of the vehicle connected to the vehicle, a digital multi-meter, a laptop computer capable of reading many data points and storing them in a data file. Many steps are involved in the O2 sensor testing. First, the vehicle must be turned on and running for no less than five minutes. The warm-up is necessary to ensure that the chemicals inside the O2 sensor are functioning properly. Next the digital multi-meter will read the output of the oxygen sensor with the vehicle at idle and driving down the road. The laptop computer must be connected to the digital multi-meter and be set to read a test point at least once every three milliseconds. We took test points are taken once every three milliseconds. Three minutes of consecutive data points are sufficient for the idle test. When graphed the data points of a properly functioning O2 sensor jumped around a lot based on vehicle's current operation, but were was always between 0 – 1.0 volts.

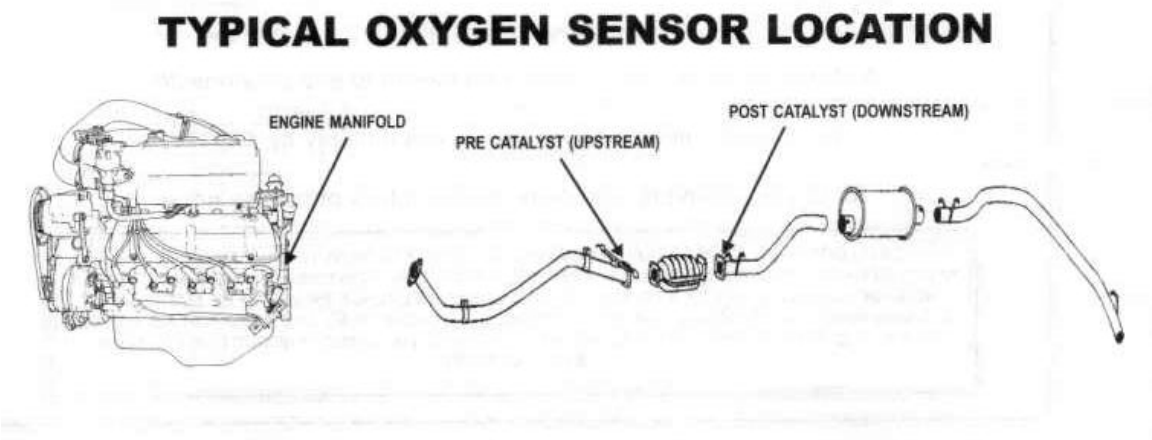


Figure 1.1 Oxygen Sensor Locations. This figure shows the three most common locations for oxygen sensors.

http://www.ece.msstate.edu/courses/design/ece4542/2003_spring/fuel_cell/docs/requirements_prod.pdf

- MAP sensors

The MAP sensor is the accrostic for **M**anifold **A**bsolute **P**ressure.

It is connected to the intake manifold on both EFI and Carbureted engines to monitor the changes in the vacuum (-ve pressure) that are occuring as you ride change speeds and vary the load via the throttle position. It is temperature compensated and uses a complex algorithm to help offset the pulsating wobble effect of the HD V twin's assymetrical firing setup.

It is a very major component of the final speed density calculation that ulimately determines the injector's pulse width required to sustain the best A/F ratio at any given time - for EFI setups. In Carburetor versions it assists in monitoring the degree of advance for the timing of the spark plugs.

There are several codes that it can throw out such as:

P0106 MAP Sensor Rate of Range Error Carb
P0107 Map Sensor Failed Open/Low **Carb**
P0107 Map Sensor Open/Low **EFI**
P0108 Map Sensor Failed High Carb
P0108 Map Sensor High EFI

The P0107 indicated that the reading was either absent or fell below the minimum range for a some period of time.

If not calibrated correctly or working properly the ECM will fix a canned value and use the other inputs to adjust the A/F ratio. It will in an EFI setup greatly affect your richness/leaness if it is skewed or not registering accurate readings.

I hope you have the sequence for checking the DTCs both current and historical as they have been posted several times on this forum in previous threads.

You will need to perform the DTC diagnostic trouble code check using the historical mode to see if it is still there. Then errase the error code, ride around and see if it returns.

More advanced systems also use a second sensor to just monoitor the Barometric Pressure and then use it as an offset depending on your elevation and the local atmospheric conditions.

http://xlforum.net/vbportal/forums/showthread.php?t=278587

The manifold absolute pressure measurement is used to meter fuel. The amount of fuel required is directly related to the mass of air entering the engine. (See stoichiometric.) The mass of air is proportional to the air density, which is proportional to the absolute pressure and inversely proportional to the absolute temperature. (See ideal gas law.) Engine speed determines the frequency, or rate, at which air mass is leaving the intake manifold and entering the cylinders.

(Engine Mass Airflow Rate) ˜ RPM × (Air Density)
or equivalently
(Engine Mass Airflow Rate) ˜ RPM × MAP / (absolute temperature)

http://en.wikipedia.org/wiki/MAP_sensor

The MAP or Manifold Absolute Pressure Sensor is a little though expensive device installed in your intake manifold, or installed on the firewall and connected to the manifold with a thin hose. It has 5 Volts or 12 Volts coming in, and it simply senses the vacuum in the manifold and attenuates (reduces, weakens) this

incoming voltage by a certain factor. In other words it reduces the supply voltage to a direct-current voltage in the range of 15% to 60% of the supply voltage (depending on the car's design these numbers will vary), and this varying (but non-pulsing) signal is then sent back to the computer.

The arrangement of resistors in the MAP Sensor Enhancer simply takes this already attenuated (reduced, weakened) signal – and attenuates it further. Too much attenuation kills the engine, it will simply shut off. Yet if you control it correctly you can lean down the mixture from the stoichiometric (a big word that simply means "balance of ingredients") which is factory set at 14.7:1 (14.7 parts of air to 1 part gasoline) – down to 20:1, maybe even 50:1 or 100:1.

This device is totally passive and will work just the same if the signal coming in is 12 volts, 5 volts, or whatever comes on the line. The diagram in the book is the SIMPLEST way of doing this. The line from the sensor to the ECU is cut, and you place a pot on the line as shown in the photo contained in the book. Further below you will see the improved enhancer based on the same principle.

http://easywatercar.com/kayakosupport/index.php?_m=knowledgebase&_a=viewarticle&kbarticleid=131&nav=0,1

- MAF sensors

The Mass Air Flow (MAF) sensor helps the computer to calculate the flow and mass of the air entering the engine. It does that by measuring the cooling effect of air flow over a heated wire element. The electronic circuit inside the sensor attempts to keep the sensor at a fixed temp.

When it is cooled more by an increased air flow, more current is needed to maintain a constant temperature. The increase in current is converted into a signal and that signal goes to the computer. In most cars this signal would be a high frequency signal. Not as high as a radio wave, but much faster changing than the (relatively) slow frequency of the Oxygen sensor.

During low air flow rates, such as at engine idle, the MAF sensor produces a lower frequency signal. During high air flow rates, such as at wide open throttle-road load, the MAF sensor increases the frequency. The control module then converts these frequencies into their corresponding Grams-Per-Second values.

Yet again, some MAF sensors may work on a straight DC signal 0-5Volts such as the typical MAP sensor. This is the case in some older MAP Sensor designs that have a trap door with a potentiometer connected to its shaft.

http://easywatercar.com/kayakosupport/index.php?_m=knowledgebase&_a=viewarticle&kbarticleid=131&nav=0,1

Schematics for the above sensor modifications

An oxygen sensor consisting of a metal electrode formed on the surface of the side to be measured of a solid electrolyte sintering and of a reference oxygen pole formed by a mixture of metal and metal oxide on the opposite side of said surface of the side to be measured of the solid electrolyte sintering body, characterized in that, at least over the whole surface adjoining the mixture of metal and metal oxide on the side of the reference oxygen pole of the solid electrolyte sintering, a porous metal electrode is formed to insulate the solid electrolyte sintering from the mixture of metal and metal oxide, thereby improving the low temperature performance and internal impedance characteristics, as well as prolonging the life thereof. A method for manufacturing this sensor is also provided.

Patent Number	Title	Issue date
4209377	Oxygen sensing element	Jun 24, 1980

4264424	Hydrogen ion sensor having a membrane sheath of an oxygen ion conducting ceramic	Apr 28, 1981
4278509	Method of activating oxygen concentration cell	Jul 14, 1981
4379741	Oxygen concentration sensor	Apr 12, 1983
5043053	Reference electrode probe for use in aqueous environments of high temperature and high radiation	Aug 27, 1991
5827415	Oxygen sensor	Oct 27, 1998
6497808	Gas sensor	Dec 24, 2002
6505398	Very high pressure miniature sensing and mounting technique	Jan 14, 2003
6605202	Electrodes for solid state gas sensor	Aug 12, 2003
6951601	Oxygen concentration detector	Oct 4, 2005

http://www.google.com/patents?id=W-41AAAAEBAJ

MAP

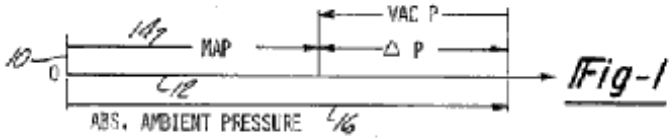


Fig-1

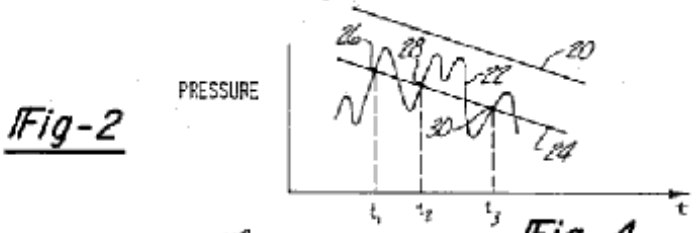


Fig-2

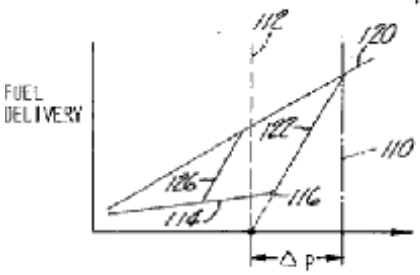


Fig-5

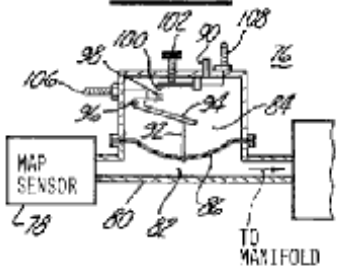


Fig-4

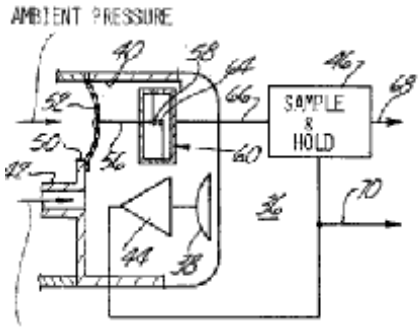


Fig-3

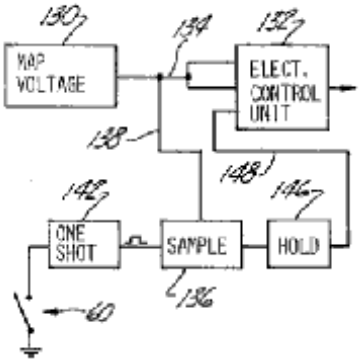
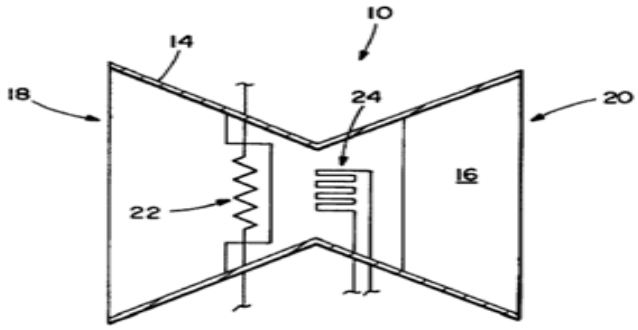


Fig-6

A combination manifold absolute pressure and ambient absolute pressure sensor utilizing a single absolute pressure sensor and a second sensor which is devised to sense the difference between the manifold pressure and atmospheric pressure. The second sensor is provided with a switch mechanism actuated by a diaphram at a preselected pressure difference between manifold pressure and atmospheric pressure. The actuation of the switch mechanism causes a sample-and-hold circuit to sense the instantaneous manifold absolute pressure at the time of actuation of the switch and electrically add the sensed manifold pressure to the set difference between the manifold pressure and atmospheric pressure to provide a signal indicative of ambient absolute pressure. This signal is utilized to provide altitude compensation in a fuel injection system.

http://www.google.com/patents?id=3zk7AAAAEBAJ

MAF



A mass air flow sensor device for determining the mass of air flowing therethrough is operatively associated with an engine control module of an internal combustion engine which uses data corresponding to the mass of air flowing to the engine for controlling the operation of the engine for increased efficiency and lower exhaust emissions. The mass air flow sensor device includes a housing having an air flow-through housing comprising an electrically resistant air temperature sensing element at the air inlet end of the housing and an electrically resistant air heating element in the housing downstream of the air temperature sensing element. The resistor of the air temperature sensing element and the resistor of the air heating element are components of a common electrical circuit. The air heating element is operatively responsive to the temperature of the incoming air as sensed by the air temperature sensing element so that the air heating element is heated to a predetermined.

http://www.google.com/patents?id=jdABAAAAEBAJ

Installation instructions

STEP 1. VACUUM Vacuum lines are supplied from the engine to various car systems, and you should best use the system that gets the highest vacuum. The idea is to suck the HHO into a place such as the carburetor or the intake manifold, where it can be automatically mixed with the existing fuel/air mixture. Connect the output to the carb/intake manifold.

STEP 2. ELECTRICAL: The device is designed to operate on 12 Volts. 3. Turn the switch off and take out the key. Connect positive (12 Volts) to the red terminal of the device, using the FUSED wire supplied (red), to the point you've identified above. 4. To protect the wiring from long term damage, you can now put the newly installed wires into what's called "split flex tubing",

STEP 3. FINAL SETUP: Fill the jar with DISTILLED WATER, leaving 1" of free space at the top. Add 2 teaspoon of Electrolyte (pure Baking Soda) to the 32oz (QUAD)HHO Generator and 2 Teaspoons to the 64oz (QUAD) HHO Generator. Close the jar. Both HHO Units should draw about 3-4 AMPS of power. More Baking Soda may be added but, make sure the units operate cool and don't overheat. Running the units too hot will create steam and that will cause a drop in mileage and engine performance.

TEST RUN

1. Start with NO electricity, by taking out the fuse or leaving one of the terminals disconnected (make sure it doesn't touch metal parts of the car to prevent fuse blowout). 2. Turn the Vacuum Adjustment Valve (sometimes called "Bubbler Cap" or just "Bubbler") fully CLOCKWISE. Then turn it half-turn COUNTER-CLOCKWISE. 3. Turn the engine and watch the bubbling action coming out of the lower end of the thin tubing inside the device (here by the way is the great advantage of having a strong glass jar instead of metal or non clear plastic – total transparency and visibility!) Gradually turn the Vacuum Adjustment Valve and watch the bubbling action in the jar. Adjust the valve until there is a small amount of bubbling action. 4. Turn off the engine. 5. Connect the electricity by putting the fuse on and making sure all connections are tight (hand force only). 6. Start the engine again and watch the electrolyzing action between the spiral electrodes. A yellowish gas (HHO) will start forming and flow toward the top of the jar. 7. Within a short time (roughly 30 seconds), you will notice that the engine starts to sound quite differently. It will sound smoother and quieter. Its RPM may be unstable for a couple minutes. This is normal – the HHO is starting to change the combustion cycle and cancels the pinging – and the engine is now adjusting to the changes. Congratulations! Your HHO Water4Gas system is now ready to go! Enjoy it.

http://www.richlandelectronics.com/inofhhoki.html

You tube video

http://www.youtube.com/watch?v=45bFrWBBjtk&feature=related
Hydrogen Electrolysis - using Flat Plates
Circuit

Safety precautions

Examples:

- wear rubber gloves when using NaOH

- Eye Goggles with side splash guards
- Heavy Duty Rubber Gloves
- Hearing Protectors
- Rain Jacket

Far and away the most important item is the eye goggles since the electrolyte would cause considerable damage to an eye. The gloves and rain jacket likewise prevent caustic burns should an accident or explosion occur. The hearing protectors would muffle the sound of an explosion should one occur.

http://hydroxygasadventure.blogspot.com/2008/06/personal-safety-gear.html

During the installation process

Work outside, no smoking; make sure the engine is not hot. Wear goggles and gloves and only use professional tools; use common sense and general safety procedures used for automotive installations and maintenance.

http://www.richlandelectronics.com/inofhhoki.html

If the temperature inside the electrolysis cell rises to above 92° C, then the water will be dangerously close to boiling. If the saline solution in the electrolysis cell starts to boil then there is an increased chance that the solution will splash out into the air intake of the host vehicle. This temperature must not be reached. We used a temperature sensor to ensure that the saline solution never comes to a boiling point.

undertaken many precautions to ensure that the splashing from the cell does not get into the system. The first precaution that have taken is to create a splashguard. The splashguard is a schedule 40 PVC grate that fits in the electrolysis cell and serves to prevent any sloshing water from sloshing into the system. Secondary precaution is a water collector. The collector will collect any water that manages to get into the hoses of the system. The collector must be manually emptied but it does not fill up very often. sloshing into the air filter side of the hose by the fact that the system is in a vacuum and air is constantly being sucked into the electrolysis cell and this air would push any collected water in the hoses into the electrolysis cell for reintroduction into the electrolysis process.

http://www.ece.msstate.edu/courses/design/ece4542/2003_spring/fuel_cell/docs/requirements_prod.pdf

The booster must not make hydroxy gas when the engine is not running. Electrical booster is rooted through the ignition switch of the vehicle.

Soldering is better than crimping. Any loose connection will cause heat and possibly a fire, so it is up to you to make sure those connections are of high quality. They must be clean and tight, and should be checked from time to time as you operate.

http://aquauto.com/sites/default/files/users/Nick_Stone/Chapter10.pdf

Data on testing that has been done.

Example-1

Ozzy Freedom a fellow experimenter conducted some experiments and discovered the following: "In my car the one jar with 3 amps was enough to give me over 52 MPG average, which is 72% gain in fuel economy. The six-cell arrangement (6 jars) was taking only 6.6 amps, so it couldn't have been much more HHO than the one (maybe double), and it got me to over 61 MPG, or 107% gain. So I doubled the mileage with a tiny little bit of HHO". "The 6 cell isn't just low amps. It is also very low maintenance - I drove 4 months without touching it, and I could go 6 or more months if I had to".

In my next experiment I'm going to make a High Yield Electrolyzer. This will require rewinding the Electrolyzer tower so that the coils are double density or only about 1/4" or 6 mm apart. I am working with another electrolyte as well, Sodium Hydroxide. This aids in producing more HHO than Baking Soda and is safer for the wires in the Electrolyzer. I will also experiment with Sodium Citrate, which is as safe as baking soda (used in ice cream). My goal is to double or triple my mileage, while at the same time getting the complete Electrolyzer set to draw less than 20 amps.

http://www.articlesbase.com/automotive-articles/how-much-hho-or-hydroxy-does-the-electrolyzer-produce-494416.html

Water sources for automotive electrolyzers

The present invention provides a self-replenishing liquid water source onboard an automobile for supplying liquid water to an electrolyzer, such as an on-board hydrogen generator useful for the suppression of unwanted emissions. While automobiles typically have water reservoirs resupplied by a person, the invention provides a passive means of water collection for reliable replenishment due to operations of the automobile itself. The invention provides condensate from the engine exhaust gas by cooling a region of the exhaust system using cooling fluid from the engine coolant system. The cooling fluid is circulated during a period following the engine cold start event when the heat load on the engine coolant system is low.

http://www.freepatentsonline.com/6464854.html

Dual-direction flow membrane support for water electrolyzers

Due to the limited structural integrity of the ion exchange membrane, operation at pressure gradients exceeding about 200 psi can cause electrolyzer failure due to the ion exchange membrane being physically forced into the holes of the screen set forming the chamber on the lower pressure side of the ion exchange membrane. Utilizing a porous sheet between the anode electrode and the screen set provides additional structural integrity to the ion exchange membrane and allows simultaneous dual-directional flow of water to the anode electrode while oxygen flows from the anode electrode, thereby allowing high pressure gradient operation.

http://www.freepatentsonline.com/5372689.html

Backfire prediction in a manifold injection hydrogen internal combustion engine

Hydrogen internal combustion engine (H2ICE) easily occur inlet manifold backfire and other abnormal combustion phenomena because of the low ignition energy, wide flammability range and rapid combustion speed of hydrogen. In this paper, the effect of injection timing on mixture formation in a manifold injection H2ICE was studied in various engine speed and equivalence ratio by CFD simulation. It was concluded that H2ICE of manifold injection have an limited injection end timing in order to prevent backfire in the inlet manifold. Finally, the limit of injection end timing of the H2ICE was proposed and validated by engine experiment.

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V3F-4SS8CG0-4&_user=10&_coverDate=07%2F31%2F2008&_rdoc=26&_fmt=high&_orig=browse&_srch=doc-info(%23toc%235729%232008%23999669985%23694607%23FLA%23display%23Volume)&_cdi=5729&_sort=d&_docanchor=&_ct=45&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=87e1d809ea8dd042c058e9f8d991bcfc

Improvements could be made in the area of size. The printed circuit board could be made smaller with some careful design and part choices. Though size is not really an issue, a smaller unit would be more attractive to potential customers. The controller could also be made with a smaller PIC that would have less wasted space and functionality. In particular the PIC should only have as many input and output pins as needed and the analog to digital conversion is not necessary at all. We estimate that the size of the controller could be lessened down to the size of a radar detector.
Connectivity is also an issue. As it is now, the electrolysis cell itself looks like an awful mess when it is properly connected and running. If some design effort were directed to general appearance, then much could be done to lessen the “project” look that our device has.
More research could be done to find the exact chemical happenings in the electrolysis cell. With this information, we could determine the correct salt to water ratio and maintain this ratio. An in depth analysis of the combustion chamber and the amount of wasted fuel that goes through an automobile’s engine would also be helpful in clearly determining the amount of benefit the electrolysis cell produces. At the time of this writing complete testing of the happenings inside of the electrolysis cell are beyond our means both financially and chronologically.
One of the main issues that our group faced during the testing of our device was that the electrolysis cell would require many new electrodes. The anode would deteriorate after about 3000 miles of highway driving. We know that, because of the hot electron effect, the anode will dissolve over time. However we have found that if the electrodes are made of titanium they will have a much longer life span. The biggest reason not to go with all titanium bolts for the electrodes is cost. Titanium bolts cost around $5.00 each not including shipping costs.
Another consideration that could result in a better design would be the shape of the electrodes. Chemistry and physics tells us that the most surface area of the electrodes will result in the most current and therefore the most hydrogen and oxygen produced. However, if the shapes were not chosen carefully it would be easy to have two electrodes that do not line up and thus produce less effect than the existing method.

http://www.ece.msstate.edu/courses/design/ece4542/2003_spring/fuel_cell/docs/requirements_prod.pdf

- examples:
  - NaOH instead of KOH
  - 18 plates instead of 16
  - 2 volts per cell instead of 3