



Economical hydrogen production by electrolysis using nano pulsed DC

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Abstract

Hydrogen is an alternate renewable eco fuel. The environmental friendly hydrogen production method is electrolysis. The cost of electrical energy input is major role while fixing hydrogen cost in the conventional direct current Electrolysis. Using nano pulse DC input make the input power less and economical hydrogen production can be established. In this investigation, a lab scale electrolytic cell developed and 0.58 mL/sec hydrogen/oxygen output is obtained using conventional and nano pulsed DC. The result shows that the nano pulsed DC gives 96.8 % energy saving.

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1. Introduction

Ever increasing petrol, Diesel and LPG mankind needs an alternate fuel. Existing fuels are consisting carbon content which leads to global warming. So researches are focused to find an alternate fuel without carbon content. Hydrogen has been proved to be a green alternative fuel [1]. Hydrogen is the most plentiful element in the Universe making up about three quarters of all the matters. The atmosphere contains about 0.07% hydrogen while the earth surface contains about 0.14% hydrogen. Hydrogen is the lightest element. The higher which enable internal combustion engine running on very lean mixtures [2]. Hydrogen has a high specific energy and very low density entailing high storage volume unless it is compressed or combined chemically with a metal alloy. The gaseous hydrogen is compressed and cooled 80K for the liquefaction storages. In metal hydride alloys associated with the nickel metal-hydride battery industry store the hydrogen with maximum volumetric and gravimetric energy densities. To store hydrogen on-board in the form of a compressed gas, a cryogenic liquid or gas dissolved in metal hydrides, a large amount is required to be stored and carried which lead increase in the over all weight of the vehicle. Electrolysis is a process that splits hydrogen from water. It results zero CO₂ emissions but it is currently a very expensive process. Energy consumption of Water electrolysis by the conventional process is 120000 KJ/Kg of Hydrogen. Table 1 Shows the electrolysis method and economical status. In electrolysis process the input power plays major role while fixing the production cost of the hydrogen. In conventional electrolysis the input power is the product of voltage and current. But in this nano pulsed electrolysis the input power can be calculated as per the following standard IEEE method. The definition of pulse power has been extended since the early days of microwave to be where duty cycle is the pulse width times the repetition frequency [3]. For microwave systems which are designed for a fixed duty

cycle, peak power (P_p) is often calculated by use of the duty cycle calculation along with an average power sensor (P_{avg}) [3].

$$P_p = \frac{P_{avg}}{DutyCycle} \quad (1)$$

In this paper the hydrogen production in both conventional and nano pulsed power are used and the power consumption is analyzed.

Table 1. Electrolysis method and economical status

Method	Process	Optimum Condition	Findings	Reference
Alkaline Electrolysis	Alkaline Solution Sodium or Potassium	50-100 °C Below 100 ° C preferable	70-80% efficiency Renewable energy is economical	Jean Pierre et al. [4]
High Temperature Electrolysis	Electro Chemical Process	800°C-1000°C	Coupled with Nuclear plant more efficient Rs.185-235/Kg	Ricardo Guerrero Lemus et al [5]
Photo Voltaic Electrolysis	Solar Arrays Electrolyser to split water	Solar power required	Production Cost : Rs 210/Kg	Andreas Poulikkas [6]

2. Materials and methods

An electrolytic cell reactor consists of anode and cathode in stainless steel material. Cathode made in stainless steel pipe 210 mm length with diameter of 25 mm and 210 mm length of stainless steel rod with diameter of 20 mm used as anode. The container outer wall is a temperature resistive PVC pipe with a total length of 300 mm and 50 mm diameter with provisions of gas leak less end cap with anode cathode connectors. Figure 1 shows the construction of the Electrolytic cell. The over flow and outlet gas flow vents are provided to insert temperature resistive hose to take out the gas.

Two sets of electrolytic cell are used in the hydrogen production. 12V DC power supply is used directly and DC power altered into nano pulsed DC power applied and compared. Nano pulsed power supply circuit for the water electrolysis based on the induction energy source (IES) circuit with a static thyristor. (SI Thy). In this circuit the gate of the static thyristor is connected to the anode through a diode. When the IES is switched ON the current through the induction coil gradually increases. When the Field Effect Transistor (FET) is switched off at a certain current level the current flow is instantly switched off and the inverse voltage is induced through the coil (LI). This circuit is the simplest and most compact [7]. Figure 2 shows the circuit diagram of the ultra pulse power supply.

From this circuit the applied parameters, voltage, current, frequency and the optimum values can be determined by variable resistance and capacitance of circuit and the production of hydrogen compared with the input power.

The Electrolytic cells are connected with the output of nano pulse circuits positive and cathodes are connected with negative. Pure water is a bad conductor hence NaOH is added to increase the conductivity. The optimized chemical concentration, optimum voltage, current and input frequency are studied with hydrogen production flow rate. The electrolytic cell outlet gas was analyzed with the help of Thermo Finigan make Gas Chromatography (GC). Input source is 0-24 volt DC power supply made by Aplab. Frequency variations supplied by Agilent make Function generator. The nano pulsed waveforms are conformed to Agilent make Digital storage Oscilloscope. The conductivity and pH values are analyzed as per method of standard. The schematics of the experimental system are shown in Figure 3. The data are collected by repeated trials and found the H₂/O₂ production rate.

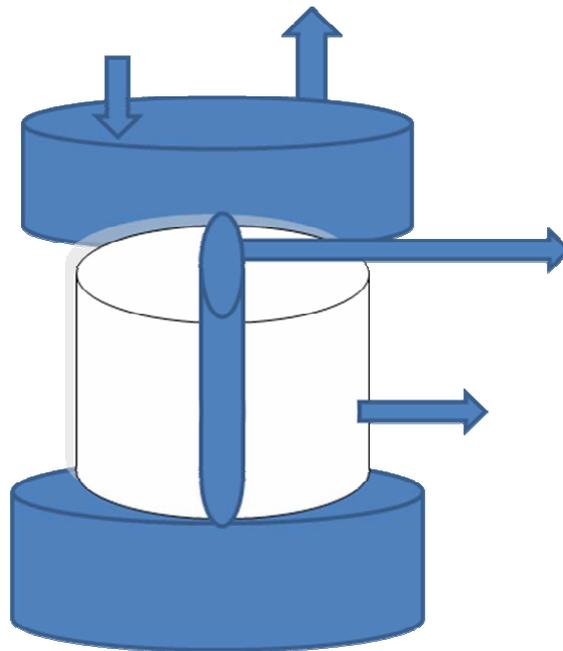


Figure 1. Electrolytic cell design

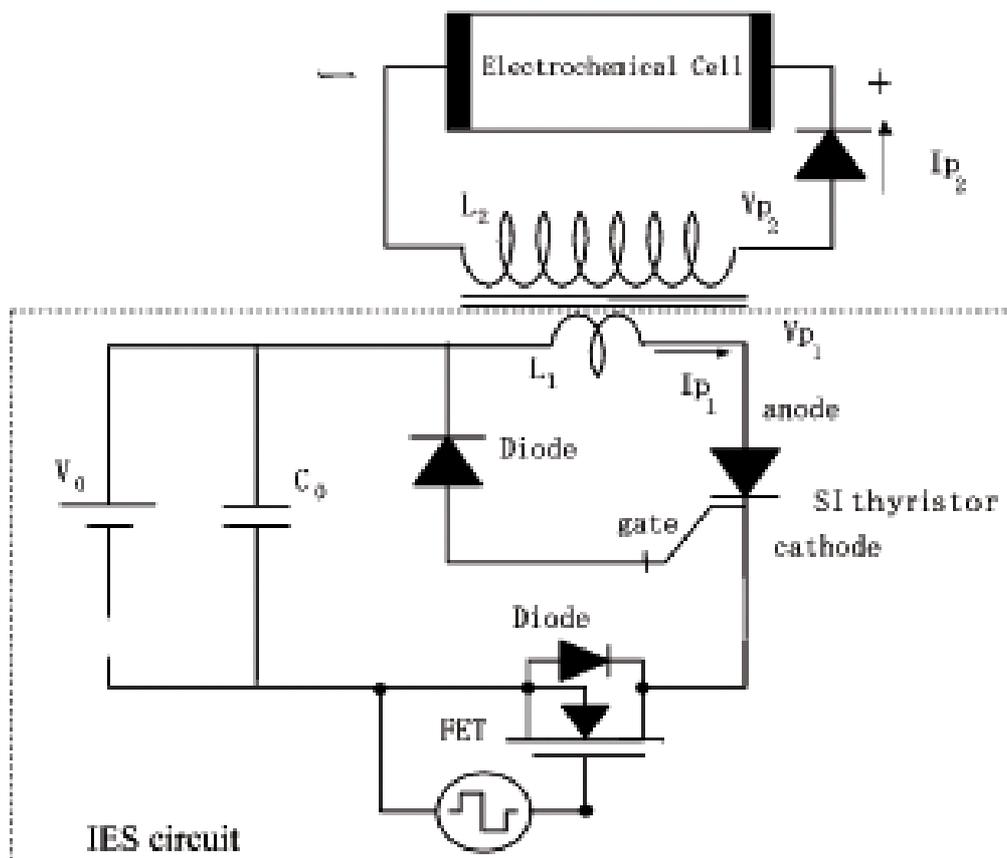


Figure 2. Nano pulse circuit

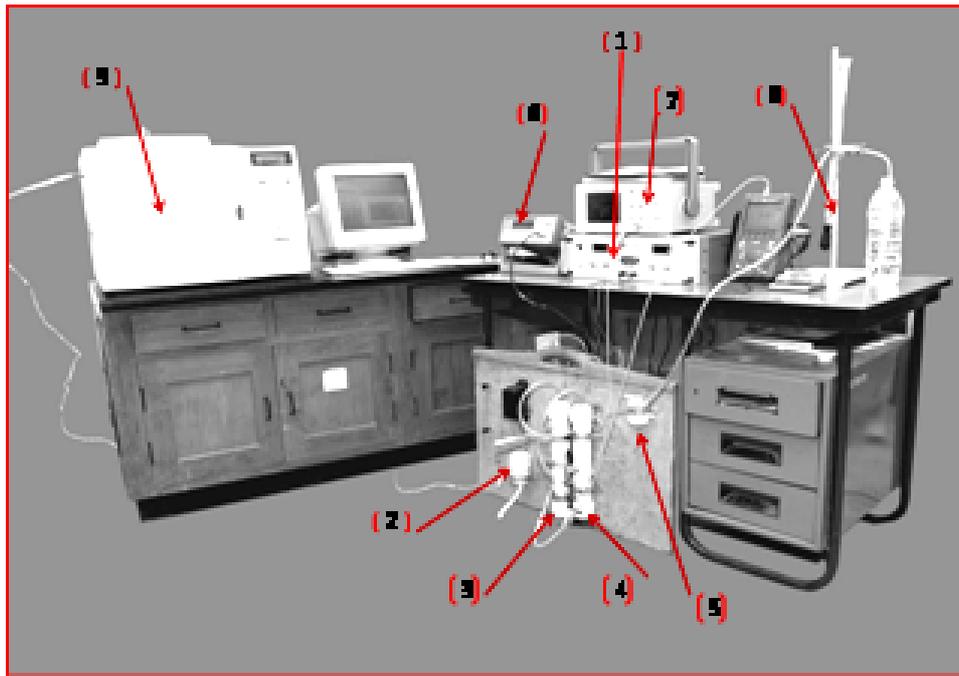


Figure 3. The schematics of the experimental system

1. Power supply, 2. Nano pulse module, 3&4. Electrolytic cells, 5. Filter, 6. Frequency source,
7. Oscilloscope, 8. Flow meter, 9. Gas Chromatography.

3. Results and discussion

In this study DC 12V power supply is used as a source of electrolytic cell and investigations are carried out in both methods and the power consumptions are studied. Increasing the electrical conductivity of de-mineralized (DM) water by adding the NaOH concentration with the ranges of 0.5- 15 g/L with the step increment of 0.5 g/L. The data are collected in each concentration steps and analyzed. From the chemical analysis it is concluded that the optimum pH value is 12.58, conductive range is 17.53 mS/cm and NaOH concentration is 4 g/L and hydrogen flow rate obtained is 0.58 mL/Sec. The conventional DC Electrolysis the power input directly applied to the electrolytic cell and the following results were obtained. The maximum hydrogen output of 0.58 mL/Sec obtained at 18 watts. Figure 4 shows the conventional DC input with the output of hydrogen gas.

The effect of nano pulsed DC electrolysis, the input power and hydrogen production rate were analyzed and the input power required is only 0.57 Watts for the same hydrogen output by the conventional DC electrolysis. Figure 5 shows the result of pulsed power effects on hydrogen production.

The pulsed power and conventional power inputs were analyzed in the Figure 6. The results show that the pulsed DC electrolysis is more effective and power savings. In maximum hydrogen output, power required in pulsed power is 0.57 Watts. Whereas the conventional DC power required is 18 Watts.

The waveforms of the input power of the electrolytic cell are obtained by the high speed oscilloscope and found that it is the pulsating pulse of 200 nano second with frequency 100 MHz which is depicted in Figure 7.

The input power required for the production of 0.58 mL/Sec with conventional DC source is 18 watts. But the application of nano pulsed power supply power required is only 0.58 Watts.

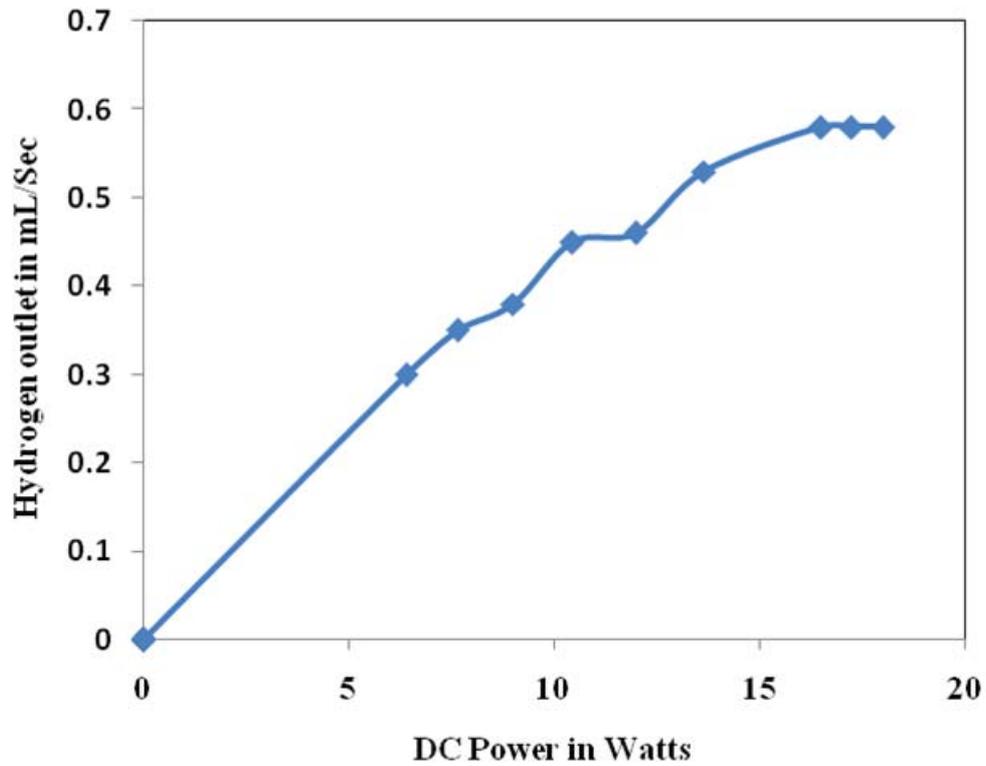


Figure 4. Hydrogen production with conventional DC power

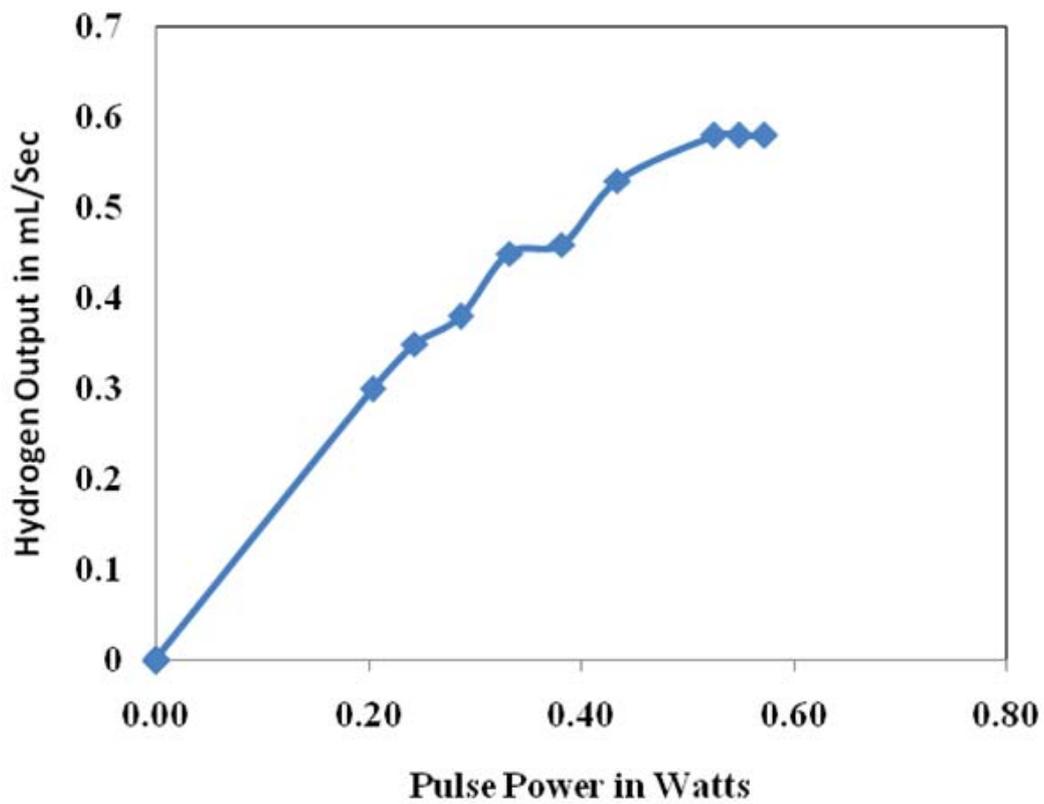


Figure 5. Effect of pulsed DC power in hydrogen production

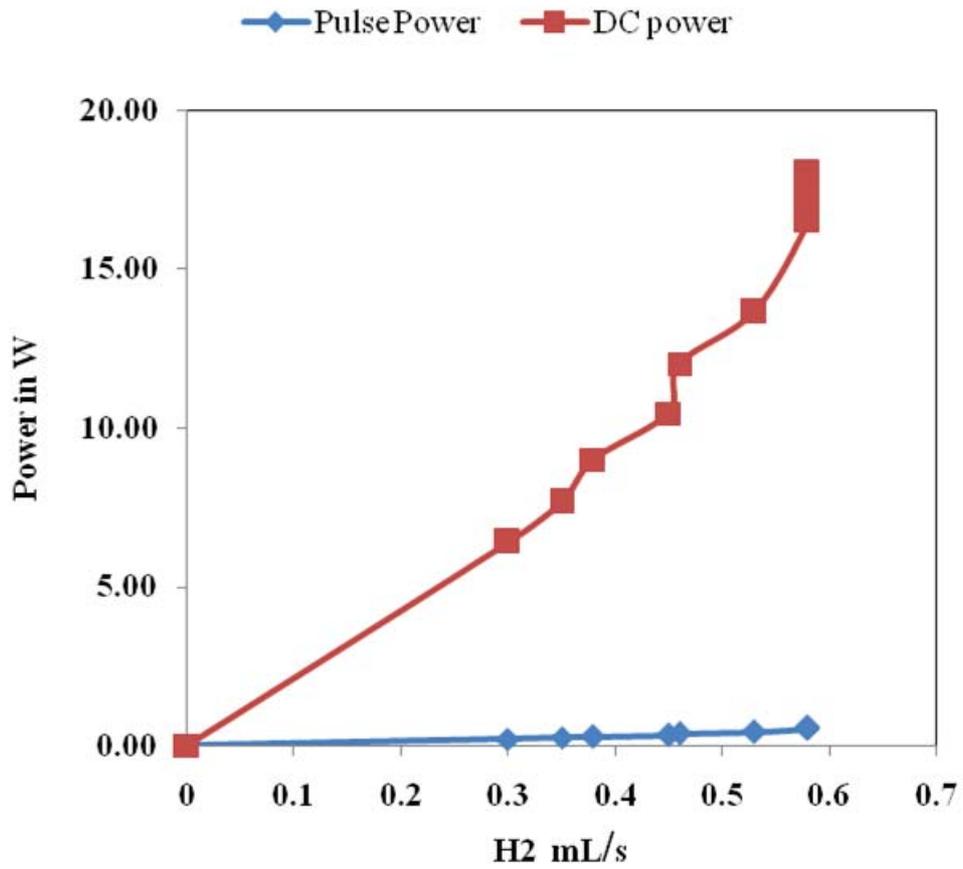


Figure 6. Effect of pulsed power and conventional power in Hydrogen production rate

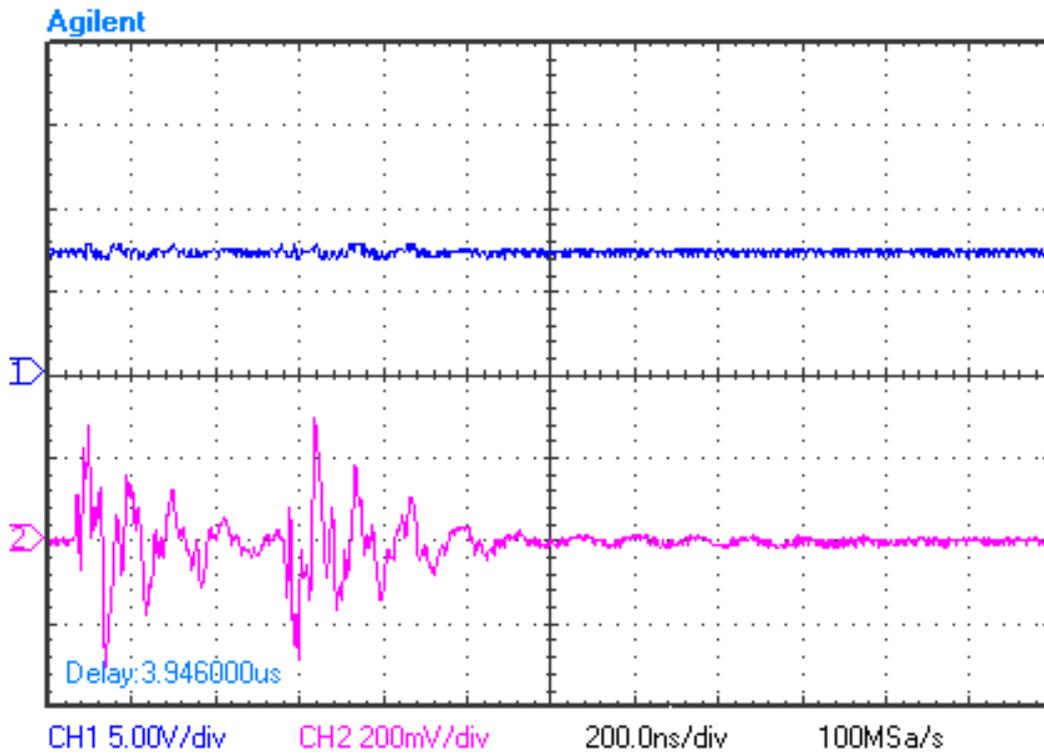


Figure 7. Wave form in pulsed power

4. Conclusion

In this investigation hydrogen production with flow rate 0.58 mL/Sec is possible with nano pulsed power and 96.8% of power saving can be achieved. Future investigation can be made to fuel saving and reduction of vehicle emission by on-board hydrogen production and it can be used in movable vehicles. Saving a drop of fuel is lead saving of natural resources. In near future this research will lead to save natural resource and safer environment.

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References

- [1] Carlos Dinamarca, Rune Bakke. Process parameters affecting the sustainability of fermentative hydrogen production: A short-review. International Journal of Energy and Environment 2011, 2(6), 1067-1078.
- [2] N.Saravanan, G.Nagarajan. An experimental investigation on hydrogen fuel injection in intake port and manifold with different EGR rates. International Journal of Energy and Environment 2010, 1(2), 221-248.
- [3] Agilent Fundamentals of RF and Microwave Power Measurement Manual for measuring pulse power, Application Note 64-1C, 2001.
- [4] Jean-Pierre Py and Alain Capitaine Report By AREVA, "Hydrogen Production by High Temperature Electrolysis of Water Vapor and Nuclear Reactors", 2006.
- [5] Ricardo Guerrero Lemus and Jose Manuel Martinez Duart (2010) "Updates hydrogen production costs and parishes for conventional and renewable technologies". International Journal of Hydrogen Energy, Vol.35, pp.3929-3936.
- [6] Andreas Poullikas (2010)"Technology and market future prospects of photovoltaic systems".International Journal of Energy and Environment Volume 1,Issue 4.2010 pp 617-634.
- [7] Naohiro Shimizu, Souzaburo Hota, Takayuki Sekiya, Osamu Oda (2006) "A novel method of hydrogen generation by water Electrolysis using an ultra short pulse power supply" Journal of applied Electro Chemistry 36(4), pp.419-423.



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