A 200 Amp Current Source with 12 V Input for Automotive Applications

by

Dr. Luke J. Turgeon, P.E

Turgeon Engineering Inc.
1829 New Holland Rd., Suite 5
Shillington, PA 19607
610-777-8267

April 22, 2014

© 2014 Turgeon Engineering, Inc.
Introduction

– Automotive need for HHO gas
  • Emissions
  • Fuel efficiency
– HHO generator design needs
  • Volume produce
  • Volume control
  • Temperature stability
– Demo
Objective of Presentation

− Understanding an HHO generator as an electrical device (i.e. I-V characteristics)

− Provide pertinent information for generator design and powering
Two plate I-V Characteristic Feb 4, 2010

3V Sweep - New plates (One set of 2 plates)
Voltage on plates measured with Keithley
50% KOH concentration (100% = 7 x 2.5 oz / gal)

Voltage (V)
Current (A)

Forward sweep
Reverse sweep
Zero crossing

5 Amps
Model Equation

\[ I = I_0 e^{V/nkT} \]
Transport Equations

\[ \nabla J_n - q \frac{\partial n}{\partial t} = q(R - G) \]

\[ \nabla J_p + q \frac{\partial p}{\partial t} = q(G - R) \]

Neg. drift + diffusion \[ J_n = \sigma_n E + qD_n \nabla n \]

Pos. drift + diffusion \[ J_p = \sigma_p E - qD_p \nabla p \]

Section 3, QRM, Wiley and Sons, 1985.
Hydrolysis Equilibrium
R-G = 0

- $H_2O \rightleftharpoons 2H^+ + O^{2-}$
Equilibrium \quad R-G=0

Phonon temperature distribution

Phonon distribution

Temperature needed to disassociate water

Phonon density

Normalized temperature (T/T_0)

H_2O

©2014 Turgeon Engineering, Inc.
Stopping Recombination by Separation R=0
Overcoming Electrical Barriers

\[ E = \frac{V}{d} \]

\[ E = \frac{J}{\sigma} \]

\[ \sigma = q\mu_n n = \frac{1}{\rho} \]

\[ R = \rho \frac{L}{A} \]
Phonon distribution at T=300 and T=350

Phonon Temperature Distribution

Phonon distribution 77C

Phonon distribution 27C

Temperature needed to disassociate KOH

KOH

H₂O

Normalized Temperature (T/T₀)

Normalized Temperature (T/T₀)
Exponential junction behavior

\[ J_n = \sigma_n E + qD_n \nabla n = 0 \]

\[ qu_n n \nabla \psi = qD_n \nabla n \]

\[ \frac{d\psi}{dx} = V_T \frac{1}{n} \frac{dn}{dx} = V_T \frac{d \ln(n)}{dx} \]

\[ n_1 - n_2 = e^{\frac{\psi_1 - \psi_2}{V_T}} \]

\[ I_n = AqD_n e^{V/V_T} \]
HHO production rate

- 2 electrons per molecule of water
  - Amp = 6e18 electrons/sec
  - Mole = 6e23 molecules = 22.4 liters (gas state)
  - One mole of H$_2$O makes 1.5 moles of HHO

- single HHO (Liters/min) = 0.011 x Amps

- 3-series HHO (Liters/min) = 0.033 x Amps
Efficiency

Enthalpy of: \(2H_2 + O_2 \rightarrow 2H_2O\)

\[
Eff = \frac{\text{Power of HHO}}{\text{Power IN}} = \frac{1.5xI}{VxI} = \frac{1.5}{V}
\]
3 cores at T=296 and T=326 with overlaid model curves resulting in ESR=4.5mOhms
Nine 3-core HHO generators at T=300 and T=320

[Graph showing voltage and current data for nine HHO generators with labels for voltage (%) at 90%, 75%, and 64%]
Measured flow rate of 3 series cores using 1 liter bottle

Flow rate of 3 series cores tested using timed 1L bottle

$\text{HHO} = \text{H}_2 + \frac{1}{2} \text{O}_2$

$\text{H}_2$

$\text{O}_2$
Two phase current source

\[ V_{IN} \]

\[ V_{OUT} \]

\[ V_L = L \frac{di}{dt} \]

\[ I_1 \]

\[ I_2 \]

Schottky

ON

OFF

L_1

L_2
dc voltage to dc current source $I_{\text{out}} = \frac{V_{\text{in}}}{V_{\text{out}}} I_{\text{in}}$
2-phase clock and gate pulses
\[ I_{\text{IN}} = 1.3\text{A}, \quad I_{\text{OUT}} = 2.3\text{A}, \quad \text{HHO} = 0.07 \text{ L/min} \]
$$I_{\text{IN}} = 13.4A, \quad I_{\text{OUT}} = 31.2A, \quad \text{HHO} = 1 \text{ L/min}$$
clock(1), comp(2), gate(3), coil(4)
I_{IN}=27A, I_{OUT}=60A, HHO=2 \text{ L/min}
$I_{IN}=43A, \quad I_{OUT}=90A, \quad HHO=3 \text{ L/min}$
Turn-OFF response
$I_{\text{IN}}=60.5\,\text{A, } I_{\text{OUT}}=118.8\,\text{A, HHO}=4\,\text{L/min}$
$A_i = 2$
Efficiency vs. Current

Efficiency (%) vs. Input Current (A)

Eff @ 12V
Eff @ 13V
Eff @ 14V
Eff @ 15V
Exhaust with 3L/min HHO into air intake
Future possibilities

- Possible use of HHO for engine cleaning and better ignition
- Valid for most liquids, liquid state technology (LST)
- Maybe useful for energy storage by converting other liquids
- Water as fuel if can fuse \( H + H \rightarrow He \)