International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 2, pp: 715-718 www.ijaem.net ISSN: 2395-5252

Simulation of Ni-MH Battery Using Dc-Dc Converter for Various Loads

Sweta Moharana[1], Dr. Sribatsa Behera[2], Dr. Kanhu Charan Bhuyan[3]
[1]*M.Tech (Electronics & Instrumentation Engineering) Dept. of Instrumentation and Electronics Engineering College of Engineering and Technology, Bhubaneswar, Odisha, India*
[2]*Professor Dept. of Instrumentation & Electronics Engineering*
[3]*Assistant Professor Department of Instrumentation & Electronics Engineering*

Date of Submission: 08-07-2020 Date of Acceptance: 23-07-2020

ABSTRACT: In today's generation, due to increase in population growth, there is an increase in demand of renewable sources.Electricity cannot backup itself on any scale rather it needs power source which can initiate the operations of the system. It can be converted to other forms of energy, which can be stored and later reconvert to electricity on demand.Focusing on these problems, researchers rerouted their track towards the backup system, which can store and utilize the electricity, by generating a regulated output as per our requirement. For these purposes, NiMHbatteries are used, as it can be recharged over time and supplies a continuous DC voltage. This paper pivots on voltage regulation, which is performed by a DC-DC converter, so that it can maintain the voltage as per the load requirement. The energy conversion is carried out by using different types of converters,comparing with various loads. This paper provides detailed analysis with the simulation done with NiMH battery in liaison with zeta converter using MATLAB/SIMULINK. For better system response, different feedback control strategies are simulated and analyzed in this paper that leads us to find out the efficient one.

Key Words: Battery, DC-DC Converter, Controller.

I. INTRODUCTION

In this paper, we have utilised a power source of Nickel –Metal Hydride Battery (Ni-MH), as it has heavy capacity, is reliable and environment-friendly. The battery is then connected to a closed loop DC-DC Zeta converter, to attain a specific required output voltage, which can overcome the voltage fluctuations of the load required. As the voltage we get via supply, is not enough to uphold the capability to fulfil the load's requirement, so a Zeta converter is used. The convertereither produces voltage, higher than that of the input voltage or produces voltage, lower than that of the input. Controller is a device generally used in feedback mechanism and widely used in industrial control systems. Here, PID Controller, Fuzzy Controller and PID-FuzzyControlleris compared to get the most efficient one.

II. ANALYTICAL STUDY OF THE SYSTEM:

Normally, a system operates by a power source. In case a power source is shut down, we make use of a battery, which initiates the operations of the system.

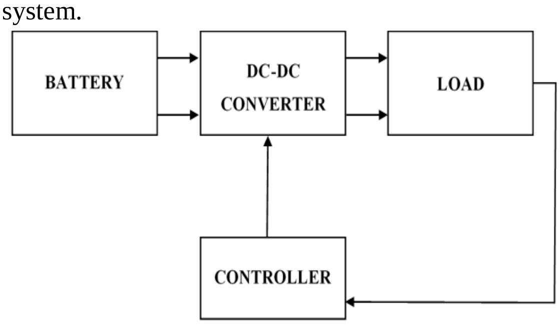

Fig. 1 Block Diagram of the proposed system

A power source of Nickel–Metal Hydride Battery (Ni-MH) is used. By comparing other batteries, Ni-MH Battery is more preferable, as it has heavy capacity, is reliable and environment-friendly.

There are different types of Batteries such as:

- Lead Acid Batteries
- Nickel-Cadmium Batteries
- Zinc Batteries
- Alkaline Batteries
- Nickel-Metal Hydride Batteries
- Lithium Ion Batteries

Based on advantages, different characteristics and properties, we have concentrated on NiMH battery which is robust, rechargeable and environment-friendly.

The nickel-metal hydride battery makes use of hydrogen for the positive electrode. This hydrogen is stored in alloy (i.e., metal hydride).

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 2, pp: 715-718 www.ijaem.net ISSN: 2395-5252

The reactions of the battery during charging and discharging are illustrated in equations below.
At the positive electrode,

$$2NiOOH + 2H_2O + 2e^- \Rightarrow 2Ni(OH)_2 + 2OH^-$$

At the negative electrode,

$$H_2 + 2OH^- \Rightarrow 2H_2O + 2e^-$$

Overall, the reaction is

$$MH_2 + 2NiOOH \Leftrightarrow \mathrm{M} + 2\mathrm{Ni}(OH)_2$$

These reactions are reversible during charging, and the equations will flow from right to left.
The charging equation for NiMH battery is,

$$E_{ch} = E_0 - K \cdot \frac{Q}{0.1Q + |it|} \cdot i^* - K \cdot \frac{Q}{Q - it} \cdot it + Laplace^{-1}\left(\frac{Exp(s)}{Sel(s)} \cdot \frac{1}{s}\right)$$

The discharging equation for NiMH battery is,

PARAMETERS	VALUES
Nominal Voltage(**V**)	7.2
Rated Capacity(**Ah**)	5.4
State of Charge at Initial (**%**)	80
Response Time of Battery(**s**)	0.3
Maximum Capacity(**Ah**)	5.4
Cutoff Voltage	9
Charged Voltage(**V**)	8.3807
Nominal Discharge Current(**A**)	2.3478
Internal Resistance(**ohms**)	0.013333
Nominal Voltage Capacity(**Ah**)	4.8835
Zone of Exponential [Voltage, Capacity](**Ah**)	[7.7788 0.2653]
Discharge Current [i1, i2, i3…](**A**)	[6.5 1.3 32.5]

$$E_{dis} = E_0 - K \cdot \frac{Q}{Q - it} \cdot i^* - K \cdot \frac{Q}{Q - it} \cdot it + Laplace^{-1}\left(\frac{Exp(s)}{Sel(s)} \cdot 0\right)$$

In these equations:
E₀ is sustained voltage, in V.
Exp(s) is dynamics of exponential zone, in V.
Sel(s) represents mode of the battery.
Sel(s) is OFF when battery is discharged,
Sel(s) is ON when battery is charged,
K is constant of polarization, in Ah^{-1}, or resistance of polarization, in Ohms.
i* is current dynamics in low frequency, in A.
i is current of battery, in A.
it is capacity which is extracted, in Ah.
Q is maximum battery capacity, in Ah.
Based on battery discharge characteristics, the parameters of the equivalent circuit can be adjusted to represent a particular battery type. A typical discharge curve in Fig. 1 consists of 3 sections:

- The first segment shows the voltage drop, which is exponential in nature, once the battery is charged. The battery type decides the drop width.
- The second segment shows the extracted charge from the battery till the voltage drops below the nominal voltage of the battery.
- The third segment depicts the total battery discharge, when the voltage drops quickly.

The discharge characteristic of NiMH Battery is shown in the figure:

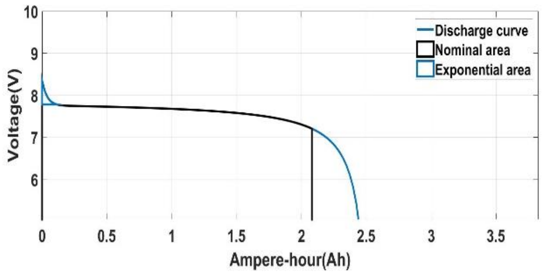

Fig. 2Graph showing typical discharge characteristic of NiMH battery

Table 1: The parameters used for the simulation of NiMH battery:

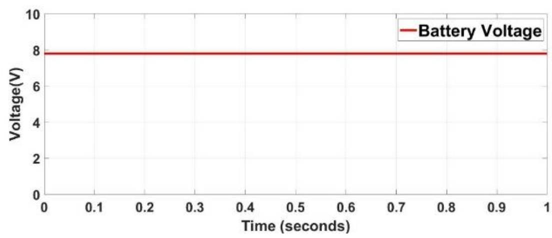

Fig. 3 Graph showing DC Output Voltage of NiMH Battery

After simulation the battery voltage is obtained as 7.802V.

III. IMPLEMENTATION OF ZETA CONVERTER

The converters are the kind of electronic circuits used for energy conversion, which converts electrical energy of the supply into the energy suitable for the load.

Now, comparing different types of converters with various loads, we use zeta converter for further work. Setting Input voltage as the battery output voltage, the table 2 shows the regulated output voltage of zeta converter with varying loads.

Zeta Converter: It is a device which consists of two inductors and two capacitors (sometimes called flying capacitors), and are used

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 2, pp: 715-718 www.ijaem.net ISSN: 2395-5252

to either step up or step down the voltage as per the requirement. It is also a fourth-order DC-DC converter. It provides better efficiency and better voltage gain than the regular buck-boost converter.

Table 2: Zeta Converter as compared to various loads

Input Voltage(in volts)	Reference Voltage(in volts)	Change in load(in ohms)	Change in output(in volts)
7.802	20	10	19.62
7.802	20	100	20.52
7.802	20	1000	21.36

Table 2 shows the output voltage of closed loop zeta converter with PID controller as its feedback. Varying the load, we can see that the output voltage is stepping up and stepping down as compared to the input but it also provides non-inverted voltage as compared to buck-boost converter. Reference value set by 20V.

Now, weanalyze that zeta converter can satisfy every fluctuations of the input and can work for both buck and boost mode and it is also non-inverted.

IV. RESULT AND ANALYSIS

For the system to achieve finer transient and steady state response, a feedback path is necessary. Controllers such as PID, Fuzzy and Fuzzy-PID are used as its feedback.

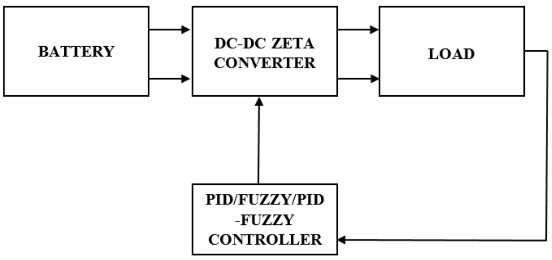

***Fig. 4** Block Diagram showing different types of controllers that are to be compared*

The significance of simulation is distinct for the introductory design of any system. The behavior and the performance of the system can be predicted by simulation. The waveform of the regulated closed loop system is designed in Simulink of Matlab, as shown in the figures.

The waveforms have been simulated in boost mode, with the battery voltage of 7.802V and the reference voltage with 15.6V.

Different Control Strategies:

Zeta Converter output waveform associated with PID Controller:

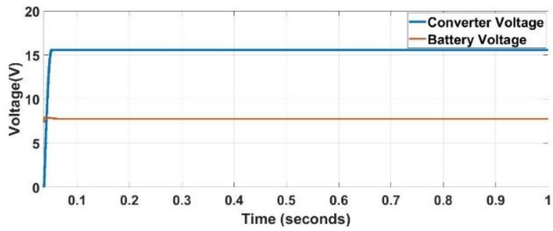

***Fig. 3** Simulated Waveform of Zeta Converter with PID controller as its Feedback*

In Fig. 5, we can determine that the rise time of the waveform is 0.030sec, along with settling time 0.039sec.

Zeta Converter waveform simulated using Fuzzy Logic Controller:

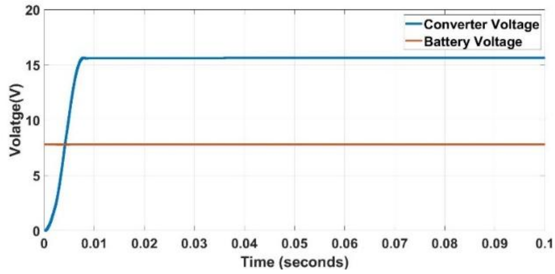

***Fig. 4** Simulated Waveform of Zeta Converter with Fuzzy Logic controller as its Feedback*

From Fig. 6, we can enumerate that the rise time of the waveform of zeta converter simulated with fuzzy logic controller is 0.004 sec and settling time 0.011 sec.

Zeta Converter waveform simulated with Fuzzy Logic Controller along with PID Controller:

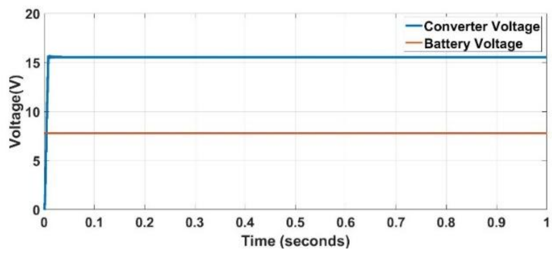

***Fig. 5** Simulated Waveform of Zeta Converter with PID-Fuzzy controller as its Feedback*

From Fig. 7, we can evaluate that the rise time being 0.005 sec where the settling time of the waveform of zeta converter associated with PID-fuzzy controller as its feedback is and 0.016 sec.

Table 3: The controllers with its time-domain variations:

CONTROLLERS	RISE TIME(in secs)	SETTLING TIME(in secs)
PID	0.030	0.039
FUZZY	0.004	0.011
PID-FUZZY	0.005	0.016

Focusing on the time-domain variations, the controllers are compared, where Fuzzy logic controller emerges with a rise time of 0.004 sec and settling time of 0.011 sec, beating the other controllers.

V. CONCLUSION

A system normally operates by a power source. In case a power source is shut down, we make use of a battery, which initiates the operations of the system. So, implementing NiMH battery to store and utilize electricity, with DC-DC zeta converter to regulate the voltage for varying loads, is our main target. Comparing the converters for both domestic and industrial purpose, we need to focus on a single converter that can operate both the functions. Keeping that in mind, simulation of converters operating with various loads, determines that zeta converter is the most relevant converter as itoffers high efficient and quick steady state of voltage, input to output DC insulation and continuous output current. It also satisfies all the requirements of the system by either stepping-up or stepping down the voltage and produces non-inverted output voltage. To sustain and achieve the desired output conditions, different types of controllers are compared with the actual condition.By generating an error signal and by calculating the time-domain variations, we can determine that the fuzzy logic controller emerges out as the most pertinent controller. Hence, the experimental results confirmed the correctness of the analysis by implementing zeta converter with fuzzy logic controller, which proves to be the most efficient model. Along with this, the result analysis, after modelling the system, gives us the perfect output which we require for further progress and research.

REFERENCES

[1]. Jihad Tarabay, Member, "Nickel Metal Hydride Battery: Structure, Chemical Reaction, and Circuit Model," in IEEE 2015, Tripoli, Lebanon, 2015.

[2]. Ying, T. K., Gao, X. P., Hu, W. K., Wu, F., & Noreus, D., "Studies on rechargeable NiMH batteries," International Journal of Hydrogen Energy, vol. 31, no. 4, pp. 525-530, 2006.

[3]. Jacek J. Jozwik, Marian K. Kazimierczuk, "Dual Sepic PWM Switching-Mode DC-DC Power Converter," IEEE Transactions on Industrial Electronics, vol. 36, no. 1, February 1989.

[4]. Sujo Oommen, Adithya Ballaji, Burri Ankaiah, Ananda M H, "Zeta converter simulation for continuous current mode operation," Sujo Oommen, Adithya Ballaji, Burri Ankaiah, Ananda M H, “Zeta converter simulation for continuous current mode operation”, International Journal of Advanced Research in Engineering and Technology (IJARET), REVA University, Bangalore, India, vol. 10, no. 1, pp. 243-248, January-February 2019.

[5]. Jeff Falin, "Designing DC/DC converters based on ZETA topology," Analog Application Journal Texas Instruments incorporated, pp. 16-21, 2010.

[6]. P. Ramesh Babu, S Ram Prasath, R Kiruthika, "Simulation and Performance Analysis of CCM Zeta Converter with PID controller," in International Conference on Circuit, Power & Computing Techologies[ICCPCT], September 2015.

[7]. M. Santos", S. Domido, J. M. de la Cruz, "Fuzzy-PID Controller vs Fuzzy-PI Controller," in IEEE 1996, *Dpto. de Informhtica y Automhtica. Facultad de Fisicas. (UCM) **Dpto. de Informhtica y Automhtica. Facultad de Ciencias. (UNED) Ciudad Universitaria, s/n. 28040-MADRID (Spain), 1996.

[8]. Udeh Tochukwu, "Effects of PID Controller on a Closed Loop Feedback System," in Conference Paper, November 2013.

International Journal of Advances in Engineering and Management
ISSN: 2395-5252

IJAEM

Volume: 02 Issue: 01 DOI: 10.35629/5252

www.ijaem.net
Email id: ijaem.paper@gmail.com