

Development of Hand Driven Battery Charger (HDBC) System

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ABSTRACT: In this paper energy saving hand driven battery charger (HDBC) was developed. The HDBC is running by using human muscle power conversion. Using a voltage regulator the conversion of such power was done. For a storage system we have used batteries and a dummy model load was attached for the implement of lighting system. With the help of this HDBC 4.8-6V battery can be charged and storage can be done by more useful way [5]. Using this system people can illuminate their houses with small energy consuming lights instead of being in darkness. Instead of making solar power a major one we have considered human muscle power for small charging lighting systems. E-biking and pedal power systems was done before as a replacement of solar energy systems [1] [2] [3].

KEYWORDS: Hand Driven Battery Charger, Conversion, Voltage Regulator, Battery Charging, LED Luminaire.

I. INTRODUCTION

In present scenario energy savings is the main awareness of the society. Every human being is very threatened about the present scenario for scarcity of energy. Energy conservation is making people more conscious in day to day life. It is being produced by using nonconventional systems and also stored. Storage can be done in battery for that also needs energy. In this paper we have tried to do some work on energy generation using human muscle power which is considered as non-conventional energy. Our goal was to build a model of non-conventional energy source for saving energy.

One of the main sources for the charging batteries in rural areas is pedal power charging system used in the paper [1]. Here transfer of energy occurs from a human source through the use of foot pedal and crank system. This technology is most commonly used for transportation and has been used to propel bicycles for over a hundred years. Less commonly pedal power is used to power agricultural and hand tools and even to generate electricity. Some applications include pedal powered laptops, pedal powered grinders and pedal powered water wells. In E-bike battery charging: Methods and circuits authors have proposed a wireless battery charging station for electric assisted pedal bikes [3]. Some third world development projects currently transform used bicycles into pedal powered tools for sustainable development. 100W battery also can be charged using three- phase permanent magnet synchronous generator [4]. Using a portable and manual generator, human muscle power is converted to three-phase ac electric power, and the electric power is stored in a battery using a battery charging circuit consists of a three-phase boost rectifier and a buck converter [4]. In this paper also a voltage regulator is used to give a constant current supply at charging to the battery. A boost converter can also be used to charge more powerful battery than the present one.

Here we have used hand driven battery charger converting human muscle power to dc voltage. Some new technologies have been reached to society using daily life routine of human activities. Such as using daily exercise cycle machines, human walking etc. During the exercise time a motor is being attached with the cycle and it runs as generator feeding the supply from human body. This generating voltage is actually charging the battery which is

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 4, Issue 12, December 2015

installed with the motor. By the process human exercise as well as the energy consumption is also done. After getting fully charged battery can work as sources of many purposes. Now some technology has also invented by using human walking, when people is usually walking if a compact charging system is attached with knee then the muscle power can charge mobile batteries. So a self charging is being done by person himself or herself. Either a battery or a walkman can also get charged by this compact charging system. A hand driven charger is hand-held, manually-operated battery charger which is closed with a motor that works as generator and creates a voltage when a handle is rotated by user. This charger feeds power from user i.e. from man power. This machine is a device which can be easily used in any non electrified place. In this generator the basic demand is to produce charging power at the time of battery charging. Using a stepper motor this generator is being designed. Except stepper motor d. c motors may also be used. A battery charger is a device used to put energy into a secondary cell or (rechargeable) battery by forcing an electric current through it. In Ohio State University [6] the projects are implemented for energy storage equalization of cycle lifetime even in [5] the distributed energy resources was discussed and implemented where Flexible Distribution of Energy and Storage Resources (FDERS)[5] a new model was developed.

II. STEPPER MOTOR USED AS GENERATOR

In this system stepper motor is used for charging of dc battery source due to lack of time and low power input from human body. The motor has full torque at standstill (if the windings are energized) and it is readily available in market, human body cannot provide continuous power so to run stepper motor a low power dissipation will be sufficient. Stepper motor is very reliable since there are no contact brushes in the motor; therefore the life of the motor is simply dependant on the life of the bearing.

III. MECHANICAL ARRANGEMENT OF THE CHARGING SYSTEM

Using a gearbox which is made up to convert one turn to eleven turns (i.e. its ratio is 1:11), this can give a very huge advantage to the charging system as when in input one revolution is done at the same time eleven revolutions will be given to the output of gear. This output is coupled with the shaft of the stepper motor by a plastic tube. So when a person is giving input to the handle, a multiplied output drives the shaft of the motor will be applied. Here in this gearbox only disadvantage is that a small backlash is working to come at its proper position. Here the stepper motor is working as dynamo and main power source of charging dc batteries.

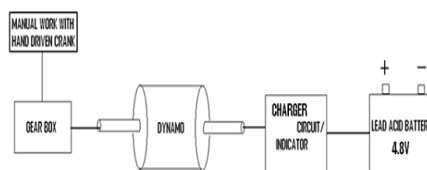


Fig 1: Mechanical arrangement of HDBC

IV. WORKING PRINCIPLE OF THE CHARGING SYSTEM

Here in this system a stepper motor has been used to generate electricity or main emf which would do the charging of the battery. A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence. The motors rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses. Here for battery charging, generator is being developed by using a permanent magnet type stepper motor. This permanent magnet type often referred to as a “tin can” or “can stock” motor the permanent magnet step motor is a low cost and low resolution type motor with

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

typical step angles of 7.5° to 15°. (48 – 24 steps/revolution) PM motors as the name implies have permanent magnets added to the motor structure. Fig 2 gives the outlook of the motor. The rotor no longer has teeth as with the Variable Reluctance motor. Instead the rotor is magnetized with alternating north and south poles situated in a straight line parallel to the rotor shaft. These magnetized rotor poles provide an increased magnetic flux intensity and because of this the PM motor exhibits improved torque characteristics when compared with the variable reluctance type [7]. Using a small stepper motor as battery charger model, voltage generation has been initially observed.

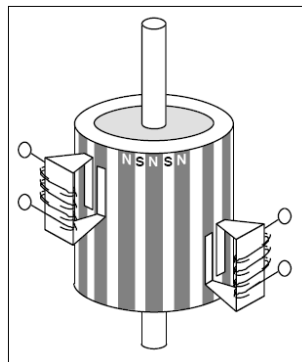


Figure 2: Outlook of a PM or tin-can stepper motor.

V. VOLTAGE REGULATOR

An ideal power supply maintains a constant voltage at its output terminals under all operating conditions. The output voltage of a practical power supply changes with load generally dropping as load current increases as shown in Fig.3.

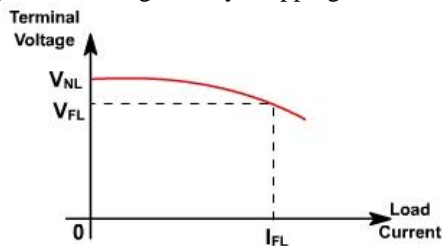


Fig. 3: Terminal Voltage Vs Load Current Curve

When full load current is drawn is called full load voltage (V_{FL}). The no load voltage is the terminal voltage when zero current is drawn from the supply, that is, the open circuit terminal voltage [7]. Power supply performance is measured in terms of percent voltage regulation, which indicates its ability to maintain a constant voltage. It is defined as

$$VR = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100 \% \tag{1}$$

Here a 5v regulator has been used for a constant voltage supply. With the help of LM7805[11] regulator circuit of this implementation has done. This regulated output voltage is fixed at a value of 5v. Here $|V_{in}| > |V_o| + 2$ volts as for the regulated output i.e. the unregulated input voltage must be at least 2V more than the regulated output voltage. From generated output voltage of the motor it is of 27-30V maximum depending on the revolution rate. So as far as the charging concerns the regulated voltage should stay upon 5V, that's why LM7805 is used. Fig 4. shows the regulator circuit.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

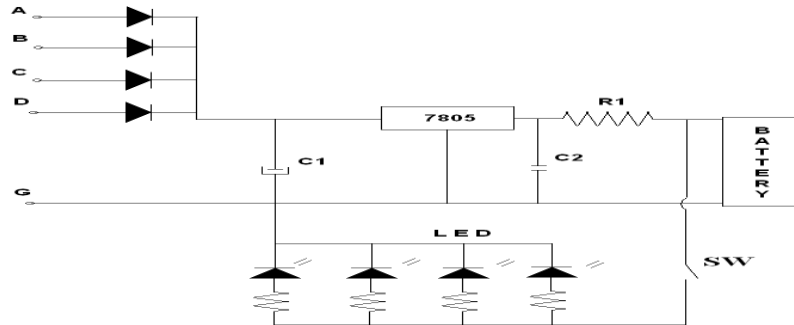


Fig:4 Voltage Regulator of 5V for HDBC

Here the charging capacitor C1 having a value of 10 μ F is used which is connected in between input terminal and ground to cancel the inductive effect due to long distribution legs. The output capacitor C2 of a value 1 μ F improves the transient response. The LM7805 IC has a temperature sensor (built in) which turns off the IC when it becomes too hot (usually 125°C to 150°C). The output current will drop and remains there until the IC has cooled significantly. Now four LEDs have been connected with the regulated output supply, when regulated voltage is being produced then the output of the voltage can be examined by the glowing of LEDs which is conducted by a switch.

VI. EXPERIMENTAL VALIDATION OF THE HDBC

In this process the generation of voltage and current using small stepper motor was very low as 20V & 3mA respectively which was not sufficient to charge 4.8-6V batteries, so a big stepper motor having a higher torque has been selected. The specification of this small motor is; torque 4 kg-cm, input 9V. After examining the small stepper motor implementation has done with a big stepper motor. The specification of this motor is-Type STM 981, torque 7 kg-cm, input 12V DC, 1 A/Phase.

Using this stepper motor voltage building up to 30V and current is also very high- 350mA at approximate 900 rpm. In Fig 5. the speed vs e.m.f. generated is shown which implies the natural characteristics of the system. In further research for the betterment of the characteristics some controllers can also be used.

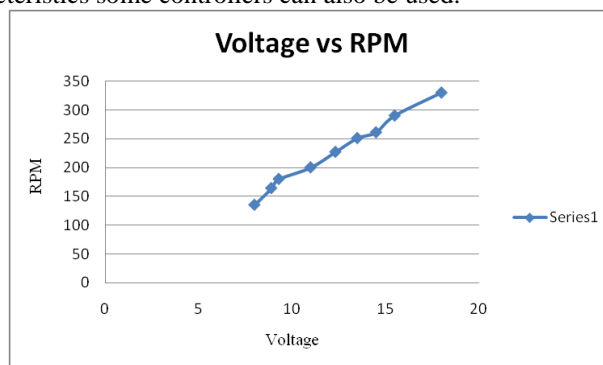


Fig 5: Characteristics of the generated voltage and rpm of the motor.

These are the values achieved after the experimentation of the HDBC.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

Table1. Motor's voltage generation with 100Ω/5W resistive load.

Input Voltage(V)	Input Current(mA)	Output Voltage(V)	Speed in RPM
2.5	2.3	8	135
2.6	2.38	8.9	164
2.7	2.4	9.3	180
2.9	2.5	11	200
3.1	2.5	13.5	251
3.2	2.53	14.5	261
3	2.48	12.33	227
3.27	2.57	15.5	290
3.4	2.54	18	330

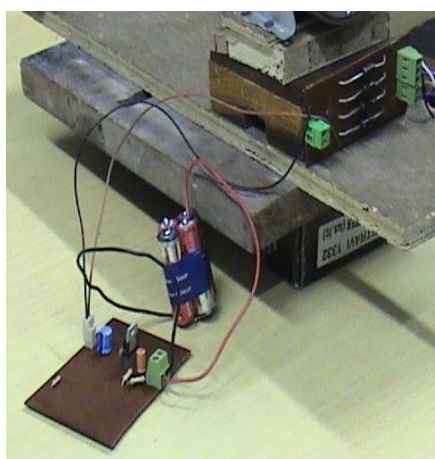


Fig 6: A prototype of the HDBC along the charging circuit.

VII. BATTERY CHARGING PROCESS OF HDBC

There are some charger schemes to charge the batteries depending on battery capacity. The charger has three key functions

- Getting the charge into the battery (Charging)
- Optimizing the charging rate (Stabilizing)
- Knowing when to stop (Terminating)

The charging scheme is a combination of the charging and termination methods.

In this system a quick charging has been occurred depending on the generator capacity. The main motive of this generated voltage is to charge a battery with the help of a charging circuit. The batteries are being charged by using a 5V regulator circuit, the rating of each battery is 1.2V, 800mA-H. The experimental results obtained while charging is given below. Here a 4.3 V battery is used, and the speed of rotation of HDBC is 550 to 700 rpm.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

Table 2: Experimental data for Regulator circuit connecting R1- value is 10 Ω.

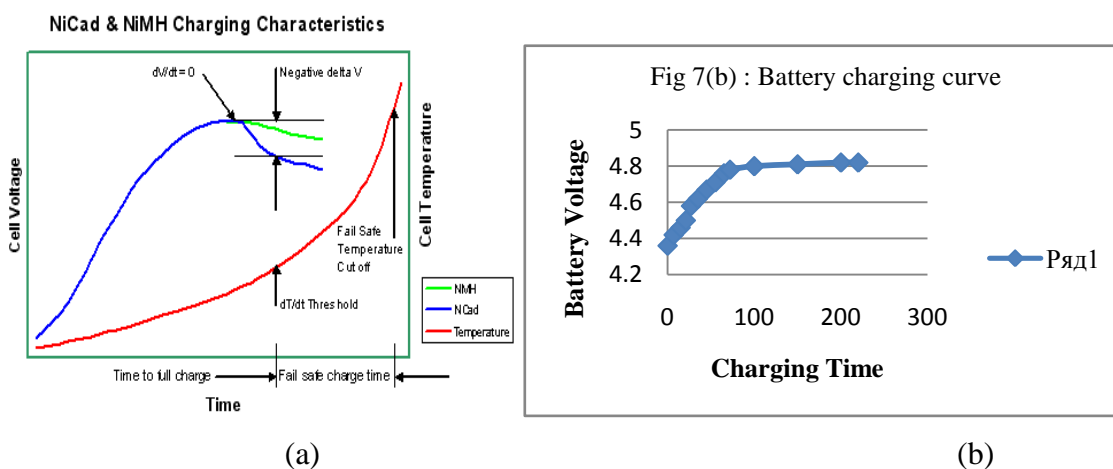
In the experiment Table 1 shows one case R1 of Fig.4 is selected 100Ω and in another case it is taken as 10Ω which is

Sl. No	Time in min	Charging Current When Regulatory resistance at 10Ω	Battery Voltage (V)
1	0	66.00	4.36
2	7	60.00	4.42
3	15	56.00	4.46
4	21	52.00	4.5
5	27	44.00	4.58
6	35	40.00	4.62
7	45	35.00	4.67
8	55	31.00	4.71
9	65	26.00	4.76
10	72	24.00	4.78
11	100	22.00	4.8
12	150	21.00	4.81
13	200	20.00	4.82
14	220	20.00	4.82

shown in Table 2. In 10 ohm the initial value of battery after discharging is 4.36V. Using regulator circuit the batteries are fully charged after minimum 220mins i.e. 3hrs and 40 min and in second case the charging time is 225mins i.e. 3hrs and 45 min.

In fig 7 the charging characteristics have shown [8]. The charge and discharge characteristics of lead-acid battery and LiFePO₄ battery is proposed in [9].

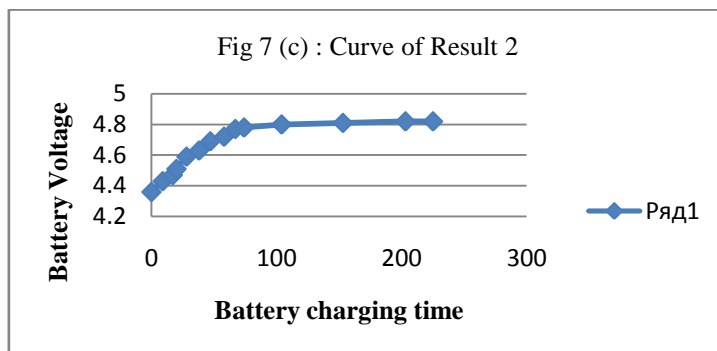
Fig 7(a) : NiCad & NiMH Charging Characteristics



International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015



(c)

VIII. APPLICATION OF HDBC

In HDBC generation a load made of four high flux LEDs is also connected with the battery for the experimental validation of the load. While rotating the hand crank of HDBC whatever the test result has come is given in Table 3, the load was connecting with a small LED luminaire [12]. The LEDs have breakdown voltage of 3.8 V. The LEDs are connected with the charging circuit in across. When the battery is being charged a switch is connected with the regulator through the LEDs, when the switch is on the LEDs will glow and if the hand crank is not revolving the LEDs would fed power from battery, when the motor is running at higher speed the LEDs glow with high intensity. The experimental tables have shown below for the load arrangement of the LED lighting systems which was used as a model load.

Table 3: For Loading with four High Flux LEDs

SI No.	RPM	LED voltage	Light O/P at 3ft Working Plane
1	560	3.9V	19 lux
2	700	4.4V	21 lux
3	850	4.5V	23 lux

After charging the energy is stored in a battery bank through the regulator, small power consumed luminaire can be ignited using this battery bank or either the low powered luminaire can be connected directly to the regulator of HDBC for power supply. When the regulator switch is disconnected the luminaire could not fed supply from battery and then it will operate from battery voltage. The discharging would be 160mA by the LEDs, so if the battery is permitted to discharge upto 70% (i.e. 560mA-hr) then the LEDs would be in full glow for minimum 2hrs and after that till 2hrs LEDs will emit light in lower value.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

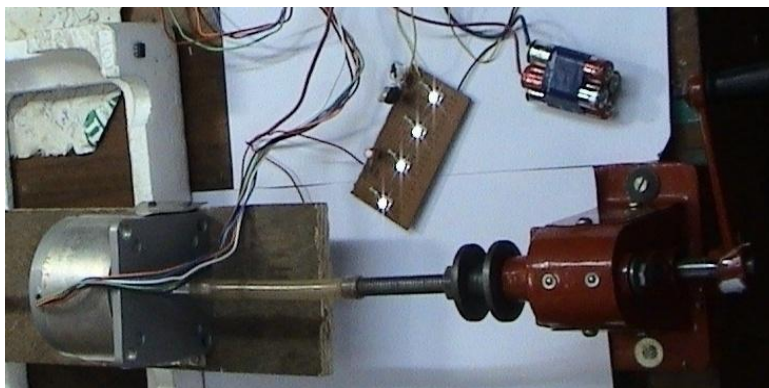


Fig 8: A prototype of the application of HDDB

IX. CONCLUSION

We have implemented an HDDB charging and generating system using non-conventional energy systems. The voltage generation can be higher in future for battery powered vehicles [13] or other instruments. We have built a model of HDDB where the generation is done using non-conventional energy source and stored in a battery bank using a voltage regulator. In various energy consumed charging systems the source is solar energy [14] wind energy or different non-conventional energy. Here in this paper a load of Hi-Flux [15] LED luminaires has been used for lower energy consumption characteristics of it. In future using LED drivers the constant current source can be attached with the LED luminaires to extend the life of the LEDs. This energy system can be easily used in rural development programmes for lightening or other domestic uses which is run by electricity. The system is very much cost effective and the results are stable enough to lighten one LED lamp of below 5W power. So the model of HDDB can be used for different power savings areas.

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