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Solar Charger for Rechargeable Batteries Used in Hearing Aid Devices

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***Abstract*—We aim to develop a device that uses solar energy to charge R13 size batteries used in BTE (Behind the ear) Hearing aid.The purpose of the following experiments is to test the electrical parameters of a Nickel-metal-hydride battery (rechargeable) R13 size used in hearing aid devices and develop an appropriate solar charger for it. The solar charger should charge the battery in a controlled manner and should not affect the battery life.**

***Index Terms*— BTE (Behind the ear) hearing aid, Rechargeable batteries, Solar charger.**

I. INTRODUCTION

Rechargeable batteries are the most environmentally friendly products of all, due to their basic reusability. We are talking about batteries used in hearing aid devices. During its lifecycle each rechargeable battery has the potential to replace up to 57 conventional primary batteries. They are nickel-metal hydride batteries in stainless steel housing. We aim to develop a solar charger that uses solar energy to charge such batteries. The charger does not affect the capacity of the battery even after frequent recharging.

II. CHARACTERISTICS OF THE BATTERY

- Voltage : 1.2 V
- Electrochemical system: NiMH
- Capacity: 31 mAh
- Diameter: 7.9 mm
- Height: 5.4 mm
- Weight: 0.9 g

III. TESTING OF CIRCUIT DURING DISCHARGE CYCLE

In a first few cycles, we will discharge the battery given with a potentiometer as a load (i.e. the discharging current is almost constant) to determine the time it takes to reach the cut-off voltage of the circuit. The battery and the resistor have previously been chosen to deliver the adequate current to the hearing aid device. The voltage of the battery and the current delivered to the load is continuously monitored. The battery is optimum for the hearing aid device as long as its voltage is above 1.1 V.

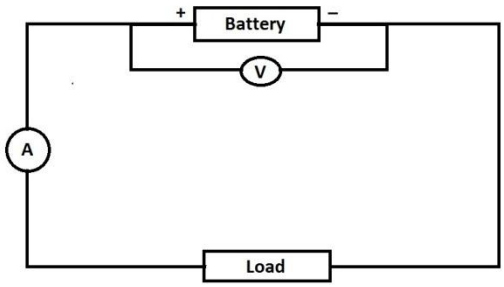

Fig. 1 Schematic circuit for Discharge cycle

IV. OBSERVATION- DISCHARGE CYCLE

The battery is discharged first with a potentiometer with resistance <= 1000 ohm. The battery is not fully charged in the first discharging cycle. The hearing aid device requires an optimum voltage of >=1.10 V. The battery lasts for 17-18 hours with an average current of 1.1 mA. The battery takes around approximately 13-14 hours to reach

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1.1 V with an average current of 1.65 mA. The hearing aid device requires varying current from 0.7 to 3.2 mA. The average current the hearing aid device requires at maximum amplification is between 1.5 – 1.7 mA. After reaching 1.1V, the battery voltage and discharging current rapidly decreases. The battery then needs to be recharged.

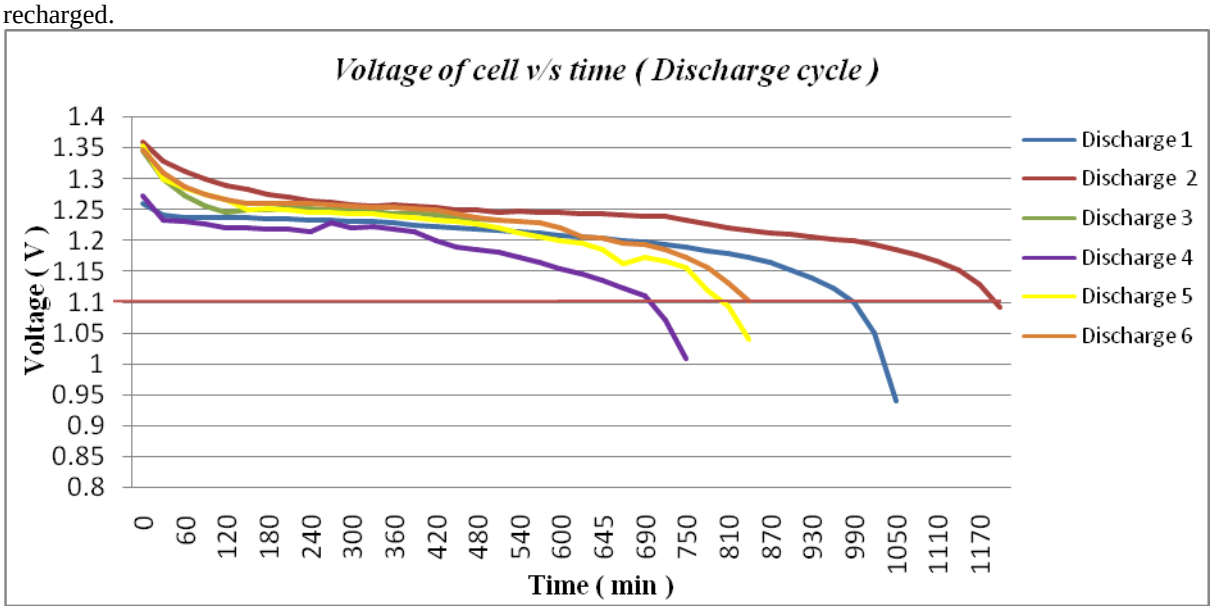

Fig. 2 Voltage (V) versus Time (min) during discharge cycle

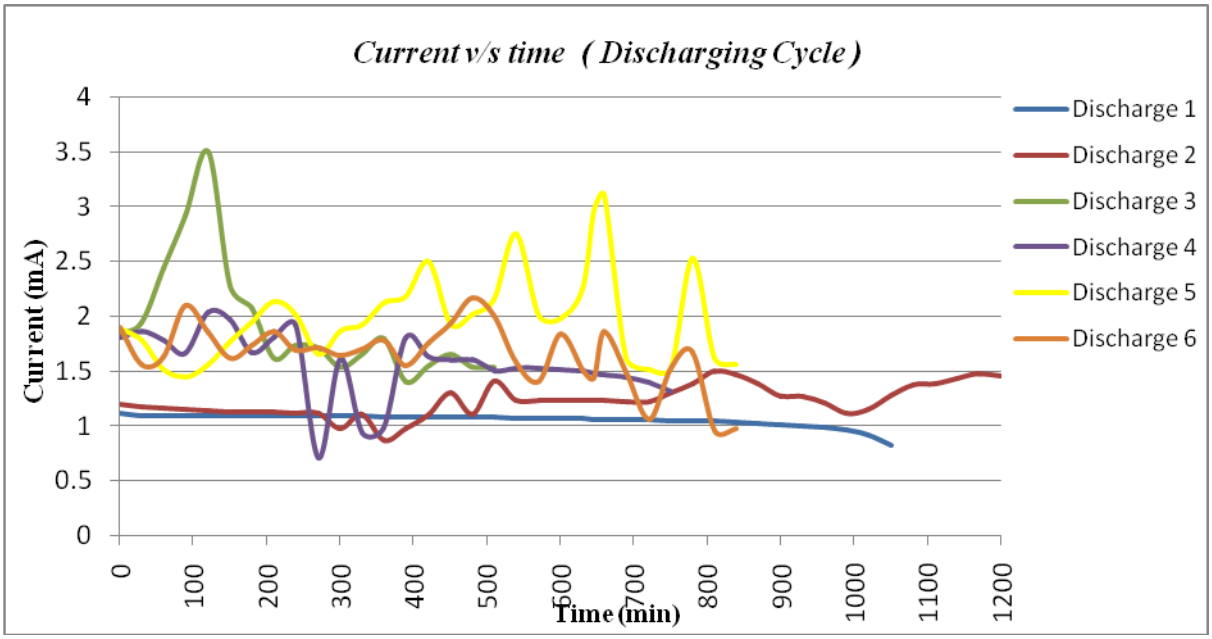

Fig. 3Current (mA) versus Time (min) during discharge cycle

V. TESTING OF CIRCUIT DURING CHARGE CYCLE– EXPERIMENT 2

This experiment will allow us to know how much time is required to recharge the battery, the voltage and the current at different times until the complete charge. We will also get to know the optimum number of solar cells to use in the solar battery charger. We will be able to determine the charging current which is optimum for the battery as well as the peak voltage of the battery when fully charged (The yellow line in graph indicates battery voltage of 1.5 V.)

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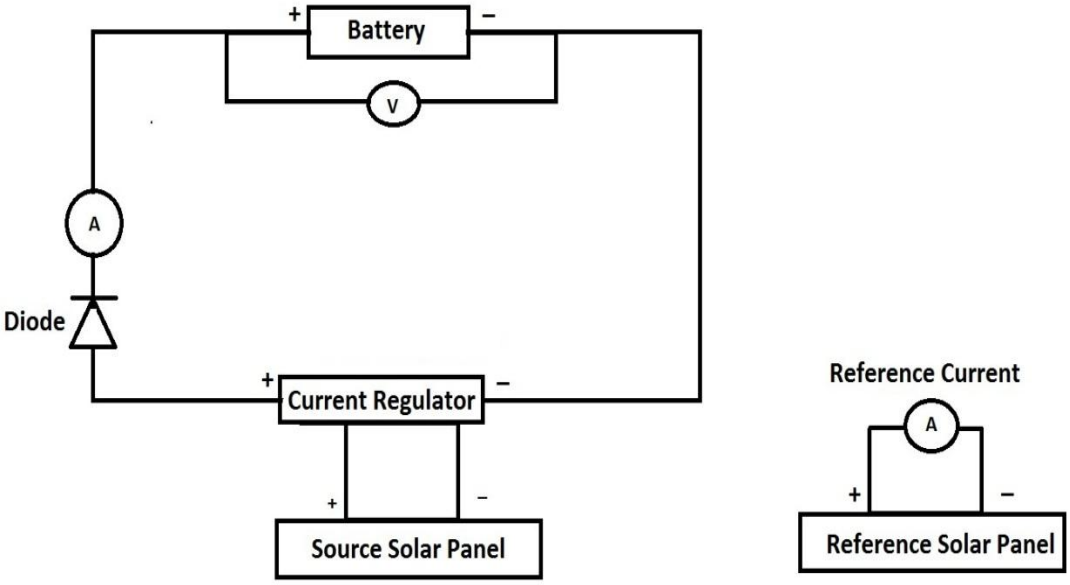

Fig. 4 Schematic circuit for Charge cycle

VI. OBSERVATION- CHARGE CYCLE

The battery takes approximately **5-6 hours** to get fully charged in normal weather conditions. The reference solar panel current varies from a peak 140mA during bright sunlight to 5mA in evening. The current regulator limits the current to a steady value of approximately 6-7 mA. The peak battery voltage when fully charged lie between 1.48 to 1.51V. The rate of increase in voltage keeps decreasing as the battery is getting charged. Limiting the current to 6-7 mA charges the battery in a controlled manner and sustains the battery life.

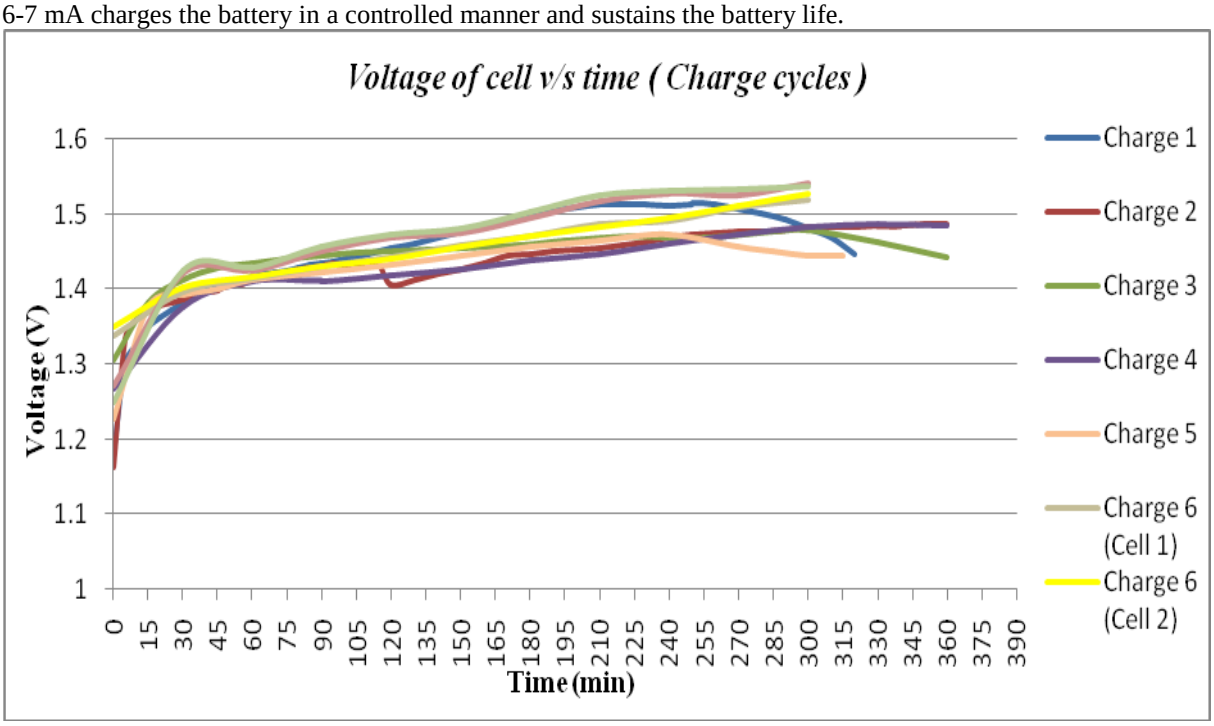

Fig. 5 Voltage (V) versus Time (min) during charge cycle

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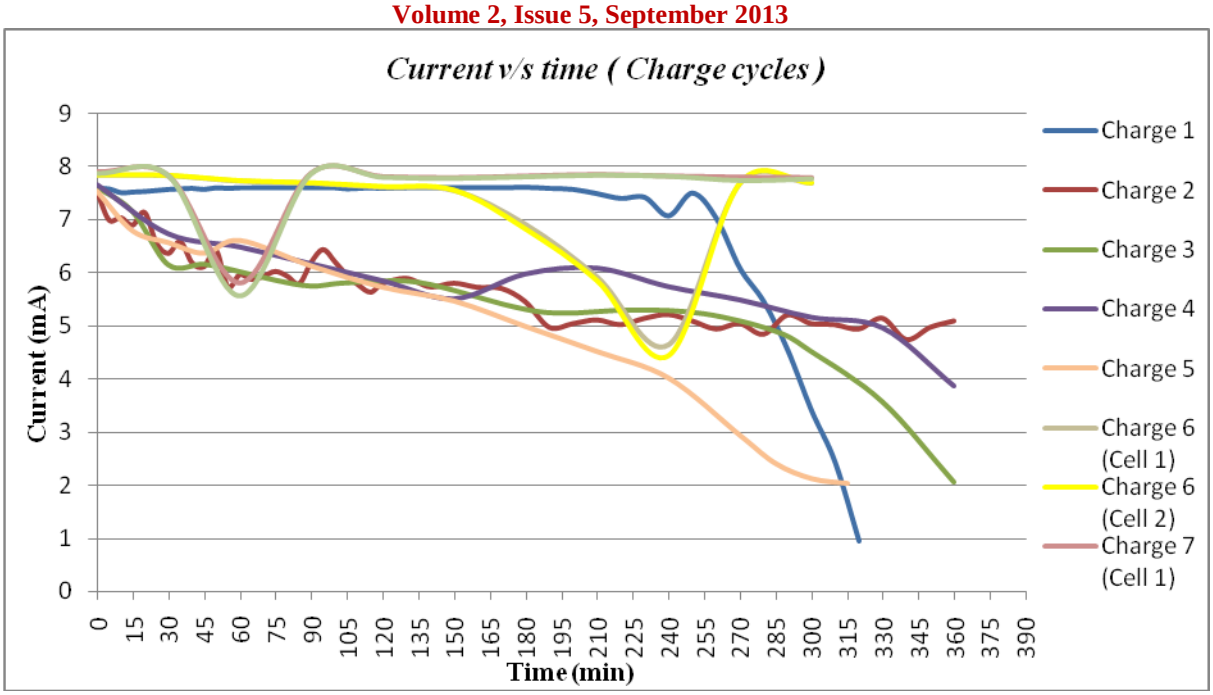

Fig. 6 Current (mA) versus Time (min) during charge cycle

VII. MODIFICATION IN CHARGING CIRCUIT

The charging circuit is modified to incorporate parallel charging of two batteries simultaneously without affecting the charging current. An extra current regulator and diode is required in the new circuit. The current regulators are connected in parallel to source solar panel. This would ensure same voltage across individual current regulators as in earlier circuit. Keeping the current regulators in parallel avoid decrease in charging current. The system can now charge two batteries simultaneously without any drawback.

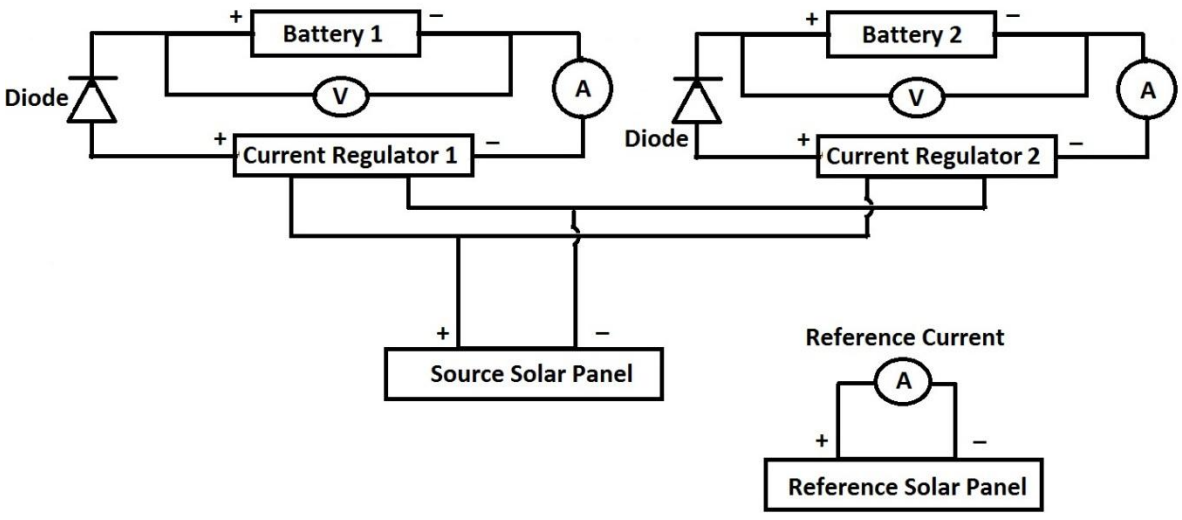

Fig. 7 Modified charging circuit

VIII. PERFORMANCE

- Each fully solar charged battery can be used for 18 to 26 hours depending on the usage pattern.
- A discharged battery can be charged in a day in almost all weather conditions.

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The solar charger takes 5 hours to fully charge the battery. Keep the solar charger on terrace in the morning and take it back in the evening.

IX. CONCLUSION

The battery takes around **5 hours of charging time** using a 3.7 V solar panel. The battery has a **discharging time of 14-15 hours**. The hearing aid can operate continuously for 14-15 hours after which the battery voltage reaches below 1.1 V and requires charging. The current regulator is designed such that it limits the input current to the battery (while charging) to 6-7 mA to avoid over-charging and damage to the battery. The fully charged battery can be used for full day to run the hearing aid device before it gets fully discharged. The battery can then be charged with the solar charger. The solar charger can charge the rechargeable battery even in diffused sunlight when the weather is cloudy.

Note: We can also charge two batteries together without any problem. Solar charger takes same time to charge two batteries as well.

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Fig. 8 Aman Goel (studying solar charger characteristics)

R.S. Hiremath (Guide) is theCEO and founder of Flexitron India Pvt. Ltd. Flexitron is a very successful company with numerous innovative products in the field of renewable energy and biomedical sciences. The company comes up with an innovative product in every 45 days, many of which hit the market.