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Characteristics of Charging And Discharging of Battery

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ABSTRACT: *This paperintroduces the main concept of batterycharging and discharging of a batterywith an intelligent charging system. with the intelligent charger, the bottlenecks in the distribution system canbeminimized. The charging system has also an option to discharge the batteries and provide backup power in the case of a distribution network failure. with the intelligent charging and discharging, the effects of electric cars on the distribution network and investmentsrelated to themcanbeessentiallyminimized.*

Keywords: *charging and discharge charcteristics*

I. INTRODUCTION

Regardless of application or battery type, knowledge of the behaviour of the battery is of great importance. Battery testing is necessary to determining its behavioural characteristics. Observation of current and voltage of a battery over a large period of time is essential for testing the battery for its capacity.

The battery finds application at various places such as common electronic gadget like mobile phone; laptops to high power application such as telephone exchange, battery run electric vehicle and HEVs. Three chemistries are widely used for secondary batteries: NiCd, NiMH and lithium-ion (Li- ion) batteries. Each of these types of batteries has their pros and cons. Many portable electronic appliances use NiCd and environmental friendly NiMH battery to cater their power requirement. These batteries have been proved to be most appropriate for its power density, size, cost, re-charge/discharge characteristics and maintenance. Due to the inherent properties, the Ni-Cd battery presents different recharging and discharging characteristics [1]. It has a flat discharge curve that the storage energy can be more efficiently released and an apparent negative increment on its terminal voltage when the battery has been fully re-charged [2]. The negative increment of terminal voltage is mostly known as the negative delta voltage characteristic of the family of Ni-Cd batteries.
This chapter will highlight the most important electrical and physical characteristics of the three most popular chemistries used in rechargeable batteries:
1.Nickel-Cadmium (Ni-Cd)
2.Nickel Metal-Hydride (Ni-MH)
3.Lithium-Ion (Li-Ion)
4.Lead acid battery

Charging Unit

A generalized block diagram of a battery charge/discharge unit is shown in fig 1 below [7]. The main components are the user interface and controller, data acquisition unit, load, charger and a temperature measurement unit. The user interface and controller allows the operator to specify the test details, control the test and store the test data. The data acquisition unit is responsible for acquiring the relevant data and returning it to the user interface. Temperature measurement is required to know excess battery temperature during charging/discharging so that a suitable action can be taken if the temperature rise is high.

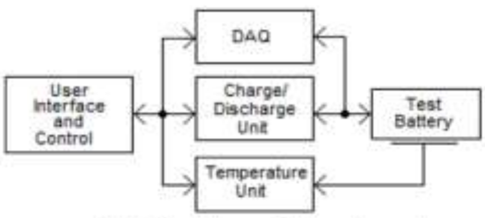


Fig. 1: Block diagram of battery charge unit

II. CHARGING AND DISCHARGING CIRCUITS

The charging circuit consists of op-amp along with a MOSFET in closed loop with unity gain as shown in fig. 3. The voltage at the source of the MOSFET equals the voltage at the control input of op-amp. A resistor R2 is connected between the source of MOSFET and the test battery.

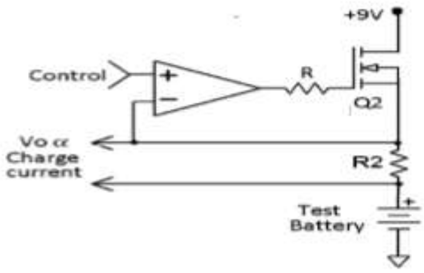


Fig 2. Schematic diagram of charging circuit

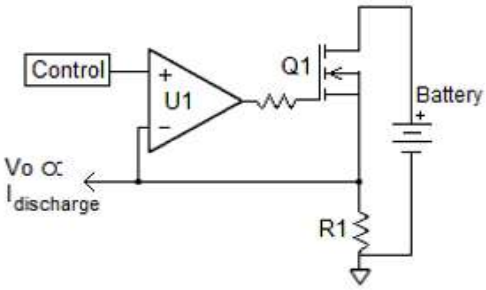


Fig. 3 shows the schematic of the discharging circuit [8]. Operational amplifier U1 drives the MOSFET Q1. The discharge current flows only through resistor R1 and hence the voltage drop across R1 is proportional to it. R1 is a high precision, low temperature coefficient resistance. Large open loop gain and low bias current of op-amp used ensures the voltage drop across the resistor R1 is equal to the voltage applied at the non-inverting terminal input of the op-amp. Battery discharging current remains constant irrespective of the battery terminal voltage if the voltage at the non- inverting terminal of op-amp is maintained at a fixed value and is equal to voltage at non- inverting/R1.

III. CHARGING AND DI.SCHARGING CURVE

The current rate "c" is numerically equal to the A-hr rating of the cell. Charge and discharge currents are typically expressed in fractions or multiples of the "c" rate.The measured terminal voltage of any battery will vary as it is charged and discharged. The MPV (mid-point voltage) is the nominal voltage of the cell during charge or dis- charge.The EODV (end of discharge voltage) point

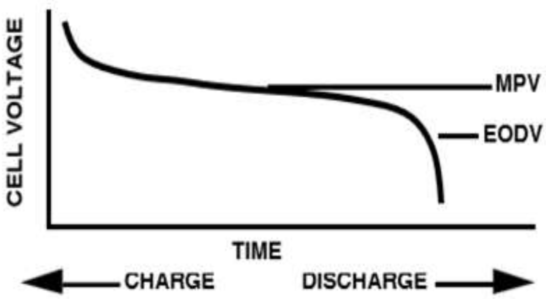


Fig 4. Charge and discharge curve

IV. BATTERY CHEMISTRIES

Many different battery chemistries are used for rechargeable portable applications, including Lithium-Ion (Li-Ion), Nickel Metal Hydride (NiMH), Nickel Cadmium (NiCd), and Lead Acid batteries. This article will focus on two of the more popular chemistries, Li-Ion and NiMH, although the topics discussed apply to the other chemistries, as well. Li-Ion batteries have the highest energy density of all battery types, making them the most portable of all rechargeable technologies. NiMH batteries are popular because they are safe and environmentally friendly. It is possible to design a mixed-signal, universal battery charger to charge both of these battery chemistries.

V. BATTERY CHARGING TERMINOLOGY

The rate of charge or discharge is expressed in relation to battery capacity. Known as the "C- Rate," this rate of charge equates to a charge or discharge current, and is defined as:

I = M x Cn

Where:

I = charge or discharge current,

A M = multiple or fraction of C

C = numerical value of rated capacity, Ah

n = time in hours at which C is declared.

VI. PREFERRED CHARGE PROFILE (LI-ION AND NI-MH)

Li-Ion battery chemistries utilize a constant, or controlled, current and constant voltage algorithm that can be broken-up into four stages: (1) trickle charge, (2) constant current charge, (3) constant voltage charge and (4) charge termination. Figure 1 illustrates these four stages of Li- Ion battery charging.

The preferred algorithm for NiMH consists of the following stages: (1) trickle charge, (2) constant current, (3) top-off charge and (4) charge termination. Figure 2 illustrates these four stages of NiMH battery charging.

Stage 1: Trickle Charge -- Trickle charge restores charge to deeply depleted cells. For Li-Ion batteries, when the cell voltage is below approximately 3V, the cell charges with a constant current of 0.1C maximum. For NiMH batteries, trickle charge conditions weak batteries, when the cell voltage is greater than 0.9V per cell "fast" charge, or constant current charge can begin.

Stage 2: Constant Current Charge – For Li-Ion and NiMH batteries, after the cell voltage has risen above the trickle charge threshold, the charge current increases in order to perform constant current charging. The constant current charge should be in the 0.2C to 1.0C range.

Stage 3: Constant Voltage – For Li-Ion batteries only, constant current charge ends and the constant voltage stage begins when the cell voltage reaches 4.2V. In order to maximize performance, the voltage regulation tolerance should be better than ±1%.

Stage 4: Charge Termination – For Li-Ion batteries, the continuation of trickle charging is not recommended. Instead, charge termination is a good option. For NiMH batteries, a timed trickle charge ensures 100% of battery capacity use. When the timed trickle charge is complete, charge termination is then necessary.

For Li-Ion batteries, one of two methods -- minimum charge current, or a timer (or a combination of the two), typically terminates charging. The minimum charge current approach monitors the charge current during the constant voltage stage and terminates the charge when the charge current diminishes in the range of 0.02C to 0.07C. The timer method determines when the constant voltage stage begins. Charging then continues for two hours, and then the charge terminates. Charging in this manner replenishes a deeply depleted battery in roughly 2.5 to 3 hours. Advanced chargers employ additional safety features. For example, with many advanced chargers, the charge stopsif battery temperature is less than 0°C or greater than 45°C.

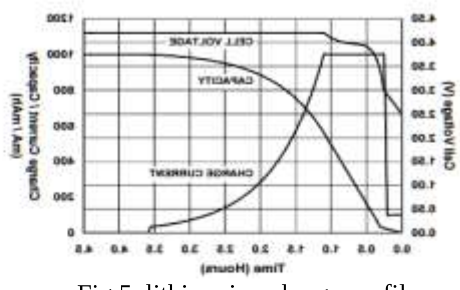
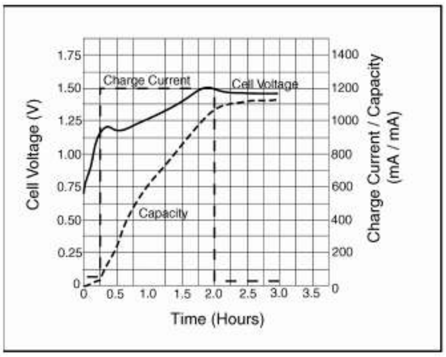


Fig 5. lithium ion charge profile

For NiMH batteries, charge termination is based on a –dV/dt reading of the battery pack, a +dT/dt (delta temperature versus time), or a combination of both. In this case, temperature sensing is a possible safety precaution, as well as a termination method.



VII. HIGH CURRENT PULSE CHARGING

The principles of current pulse charging is by applying large currents into the battery at periodic intervals with a defined pulse width to reduce or avoid gassing and thus increase charge acceptance and efficiency. Research show that pulse charging method produce significant reductions in charging time and increase the battery cycle life [11]. Experimenting test show that when applied to specific battery and compared it to other conventional charging methods, it show improvements in charging time of an order magnitude and improvements in battery life by three to four times [9]. Current pulse charging uses a circuit that consists of mirco-controlled current source, synchronous rectifier, supervisory microprocessor and personal computer for interfacing. The designed circuit supply up to 100amp current pulses for charging or discharging of lead acid battery. It also provide constant charge and discharge currents but with much lesser value.

Nickel-cadmium alkaline batteries have gained respect as a very reliable, long life electrochemical system from their performance in (4-1) industrial starter and standby service and in the space program. Space batteries were sintered plate type cells, hermetically sealed, requiring precision workmanship and very high quality control on the manufacturing line. Their chief disadvantage for use in terrestrial solar photovoltaic systems is their very high cost. Industrial nickel-cadmium batteries with lower cost are commercially available for starter, standby and cycling service. These are normally pocket plate types which are vented to the atmosphere through resealable vents in each cell to relieve abnormally high internal pressures without spontaneous oxidation of their cadmium negative plates by atmospheric air. Industrial pocket plate cells are suitable for solar photovoltaic systems and can be considered by the system designer.

VIII. CONCLUSIONS

The work contributed about the testing and performance improvement analysis of charging, discharging and thermal characteristics of various capacity rating battery banks. By analyzing the performance improvement characteristics suitable battery bank capacity rating can be predicted particular battery refurbishment applications. Enormous amount of power can be saved by after refurbishment of existing aged battery banks and replacing the identified quick discharge cell in the battery string by energy efficient batteries obtained. The obtained experimental results shows that the power consumption, heat emission and fuel consumption of batteries is less when compared to before refurbishment of various capacitates battery banks. The improved ampere-hour rating and backup time level of refurbished battery banks hold best performance when compared to before refurbishment and improved power saving for future.

In future, the proposed work can be further extended to power factor improvement of Miracle Charge System (MCS) machine provides good result in achieving lower power consumption for battery refurbishment.

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