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AUTOMATIC TWO STATE RAPID CHARGER FOR LEAD ACID BATTERIES

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This battery charger which can charge a lead acid battery in constant current charging mode after its deep discharge and can switch over automatically to constant voltage charging mode when battery terminal voltage reaches its gassing potential region, yields smooth and quick charging of the battery. In this paper hardware description of the battery charger developed at EEI division, CECRI, along with experimental results and conclusions are discussed.

Keywords: Potentiostatic charging, galvanostatic charging, MOSFET

INTRODUCTION

It is well known that in order to get a reliable, long life from a battery, apart from well designed and produced battery, the charging method adopted and the type of charging equipment used also do influence the reliability and life of the battery in any application. Both overcharging as well as undercharging are detrimental to the battery. Moreover the charging duration is also an important aspect which will have direct bearing on the usefulness of the battery to deliver the required output to the load requirements. So a simple, efficient, quick charging system is necessary to ensure that the battery capable of delivering a reliable long service life in any application. The new generation valve regulated lead acid batteries VRLABS are in general charged in constant voltage mode limiting the 'on charge voltage' of the battery at or below the gassing voltage. This voltage limitation is necessary to prevent the 'water loss' which if not controlled, will lead to battery 'drying out' stage and ultimate failure of the battery. This single step constant voltage charging method usually takes longer duration to recharge the battery fully, especially after a deep discharge. Whenever the time duration available for charging is less, the battery does not get charged fully and this may lead cumulative undercharging of the battery.

And this will result in reduced capacity output available from the battery. Hence the reliability of service is lost. These problems can be overcome by employing two step charging method, which makes use of both constant current charging, and constant voltage charging. The constant current charging mode is employed in the beginning at fairly a high current of 0.3 to 0.4 C till the battery reaches the gassing voltage. Because the charge acceptability of the battery is high at low state of charge, the charging current is completely used for active material conversion reaction and the 'on charge voltage' of the battery rises slowly at a lower rate. As soon as the 'on charge voltage' of the battery reaches the preset voltage, the charging is interrupted and switched over to the constant voltage charging mode. In this mode of charging, the charging current takes an exponentially decaying profile as the difference between the charger output voltage set and the battery terminal voltage tends to zero.

It may be observed that nearly around 85% of the input required is provided in the first step of CC mode and the balance is during the second step CV mode. Thus the total duration of charging is reduced substantially and an efficient quick charging is achieved by means of an elegant hardware design used in this two step Automatic battery charger. The operational amplifier based galvanostatic and potentiostatic controllers are incorporated in the constant current mode and constant voltage modes respectively. The high power MOSFET drivers incorporated in the charger provide an excellent isolation between the control circuit and the high power charging circuit.

The charging parameters data obtained during the charging of a 6 V 10 Ah VRLAB is given in Table I. It may be seen that the automatic battery charger is able to complete the full charging within a period of 5 h whereas a conventional charger will require at least not less than twelve hours to carry out the same.

TABLE I: Charging at constant current rate - 3A

Time hrs	Battery terminal voltage in V	Remarks
10.0	5.80	OCV
10.0	5.85	CCV
10.1	5.88	
10.2	5.91	
10.3	5.99	
10.4	6.03	
10.5	6.09	
11.0	6.14	
11.1	6.19	
11.2	6.24	
11.3	6.28	
11.4	6.33	
11.5	6.37	
12.0	6.41	
12.1	6.46	
12.2	6.51	
12.3	6.57	
12.4	6.63	
12.5	6.78	
13.0	6.93	
13.1	7.02	Change over to CV mode set at 7.2 V

EXPERIMENTAL

Hardware description

As shown in the schematic diagram in Fig. 1, the electronic hardware comprising both galvanostatic and potentiostatic charging circuits is incorporated with a charging mode controller. The charging mode controller enables galvanostat to provide CC charging mode during the period when the battery voltage is less than the gassing voltage. When the battery voltage reaches the gassing voltage, the controller enables potentiostat to provide CV charging mode. Thus automatic switch over from CC charging mode to CV charging mode takes place with the aid of the charging mode controller. The controller incorporated with an operational amplifier, OA2, configured as a comparator, compares the battery terminal voltage measured by a differential amplifier, OA1, against gassing potential as set by a potentiometer, P1, connected to the comparator input. So long as the battery voltage is less than the gassing voltage, the controller drives the high power MOSFET switches, SW1 and SW3 to enable the battery to be charged in CC mode which will be maintained by the operational amplifier, OA3 functioning as the galvanostat. The MOSFET switches SW1and SW3 if get switched on to conduction, by comparator and galvanostat respectively, it enables galvanostatic control circuit to take over the constant current (CC) charging mode of the battery.

In galvanostatic control circuit, the galvanostatic control input voltage, selected using the potentiometer P2, is to obtain the set value of constant current with definite amplitude of the charging current which depends on the voltage drop across the high watt high precision resistor Rx. At the same time, the input voltage level, to be compared with that of the battery voltage, which is set through the potentiometer P1, is to be suitably selected to match with that of gassing potential value. Battery starts getting charged in, CC mode with a current (0.3 to 0.4 C) set by potentiometer P2. During constant current charging the 'on charge voltage' of the battery will build up gradually. So long as the battery terminal voltage remains below that of its gassing potential as set by the P1 potentiometer connected to the comparator of the two state controller, the CC charging mode remains in operation through the high power switches SW1 and SW3 being driven by the comparator and the galvanostat of the controller respectively.

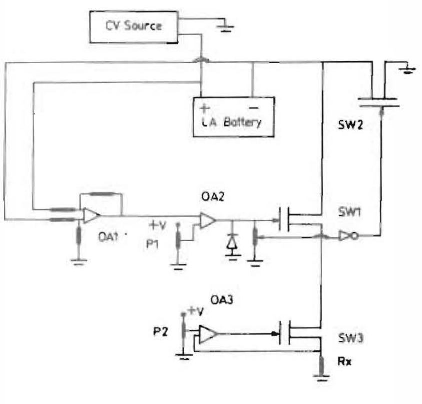

Fig. 1: Electronic hardware circuit

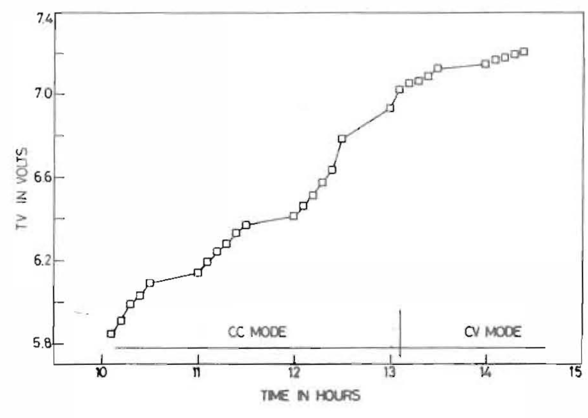

Fig. 2: Plot of battery voltage vs time

TABLE II: Charging in CV mode at 7.2 V

Time Hrs	Charging current in A	Battery TV in V	Charge input in Ah	Remarks
13.1	1.40	7.040		Change
13.2	1.20	7.050	0.217	over to
13.3	0.90	7.070	0.175	CV mode
13.4	0.80	7.080	0.140	with an
13.5	0.70	7.120	0.125	initial
14.0	0.60	7.140	0.108	current of
14.1	0.50	7.160	0.092	1.40 A
14.2	0.45	7.170	0.076	
14.3	0.43	7.185	0.073	
14.4	0.40	7.195	0.070	
14.5	0.30	7.200	0.060	Charging
15.0	0.20	7.200	0.040	stopped

When the battery terminal voltage reaches the gassing potential value, the comparator output falls to zero which disables the switch SW3. This in turn stops the constant current charging mode. The inverted output of the comparator realized through the NOT gate, goes to high state driving the switch, SW2 into conduction , which in turn enables to switch over to constant voltage charging mode. As the constant voltage source is set to be at the value of 7.2 V, the battery is allowed to get charged from 7.02 volts to 7.2 V. The pattern of the charging current in this CV mode is an exponentially decaying curve which is high current initially when the battery voltage is 7.02 V, after wards when it increases up steadily towards 7.2 V, as the difference between the termination voltage, 7.2 V, and the battery voltage gets narrowed down and so is the value of charging current which tends down towards zero value automatically.

CONCLUSIONS

As depicted in Tables I and II.and in graphical plot of battery voltage Vs time in Fig. 2 obtained during 5 hr rate capacity test carried out on 6 V, 10 Ah MF battery, the battery system is found to complete its charging cycle within 5 hours, when it is charged by the developed two state automatic charger.

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