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A PROGRAMMABLE MULTIPURPOSE CHARGING SYSTEM FOR ELECTROCHEMICAL SECONDARY POWER SOURCES

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Design details of a microprocessor based multipurpose battery charger is described. The main characteristics of the charger are that it can be CC or CV mode charging, with desired taper charging or multistep charging variations. Provision for temperature sensing of the battery and corresponding charge corrections are built in.Software for three types of charging is described.

Key words: Secondary power source, microprocessor, multipurpose battery charger

INTRODUCTION

Due to the evergrowing demands in the energy sector, immense developments are taking place in the field of electrochemical energy sources. The production of existing systems are being increased due to emerging applications like energy storage and electic vehicles. Efforts are being made to exploit new systems. This has necessitated proper maintenance of storage batteries, of which charging procedures have much significance. Constant current, constant voltage, tapered charge, and combinations of these procedures are the commonly adopted practices. Nevertheless, revolutionary charging principles like burp charging [1], multistep charging, etc have come into existence. However, there remain many problems which need attention. Efforts are being oriented towards precise charging in minimum time.

This paper treats the design details of a microprocessor based multipurpose battery charger possessing the following characteristics: (1) The charger is capable of functioning either in constant current or constant voltage mode (2) Precise and efficient charging will be done (3) Efficient charging procedures like two stage tapered current charging and burp charging can be performed (4) The operations of the system can be expanded so as to detect temperature extremes and control or terminate charging (5) The system can be modified to charge any kind of electrochemical power source.

SYSTEM HARDWARE

The hardware is divided into three sections: first the microprocessor section with its associated memory (RAM and EPROM), seven segment LED display unit and keyboard matrix; secondly the Z-80 PIO with its power supply section, DAC and range and function control section; and third, the ADC for monitoring the battery charge voltage and current for controlling the DAC and power supply unit (charger) by CPU. The aim is to develop low cost system and to study only a single battery. However with data acquistion hardware modules, this system can be extended to monitor and control charging of many batteries.

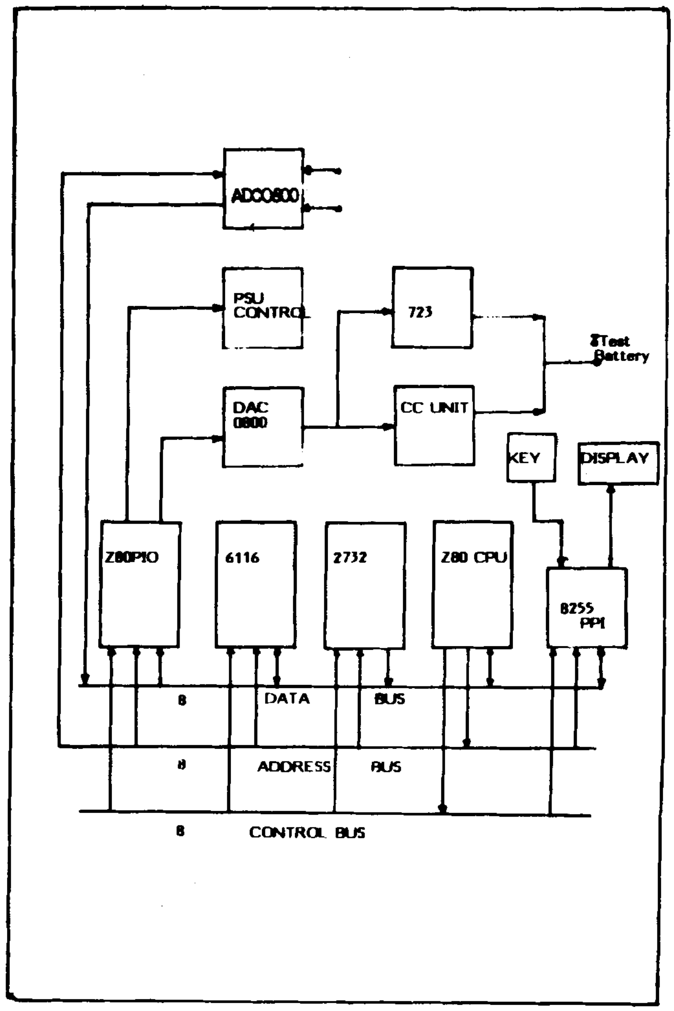

Fig. 1: Block diagram of the programmable charger

MAIN BOARD (Fig.1)

The main board is SPEZ-80: it consists of Z-80 CPU, programmable peripheral interface 8255 for interfacing the keyboard matrix and LED display unit. The memory used is 8k EPROM (i.e. 2X2732) for system monitor program and the main program;

and 2k RAM (6116) for temporary data entry and storage by user. The CTC Z-80 PIO are daisy chained with CTC having highest priority interrupt.

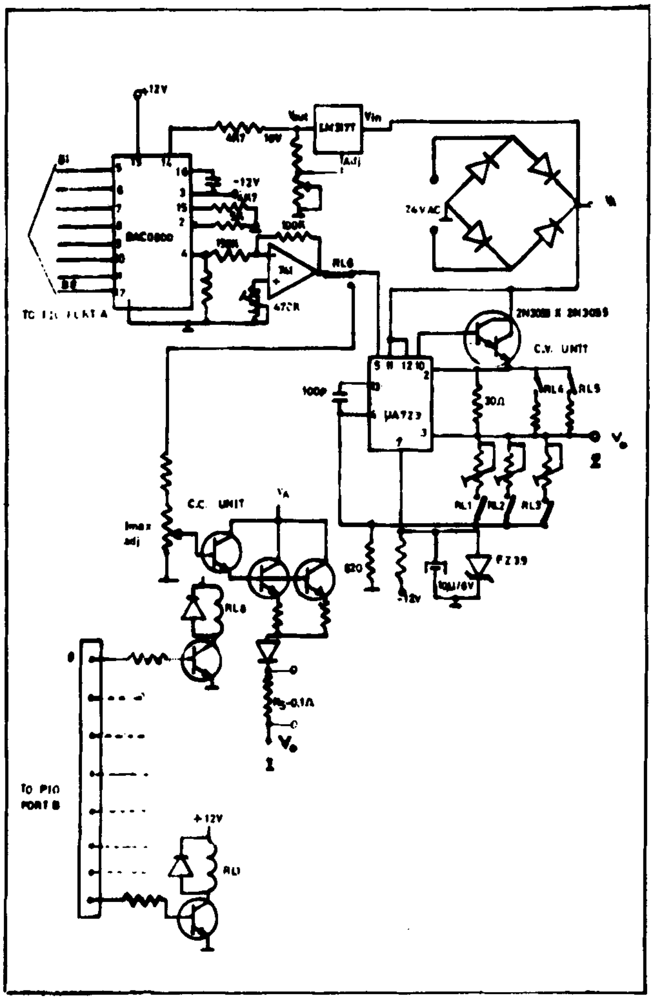

Fig.2: Power supply interface

POWER SUPPLY INTERFACE (Fig.2)

The 723 based voltage regulator and bipolar transistor current regulator are interfaced to the port A of Z-80 PIO of the main board through a 8 bit D/A converter DAC 0800. The output E_0 of this IC (DAC) supplies a high impedance analog voltage which is proportional to the 8 bit binary word. The 8 bit data from data bus of the programming section travels through the Z-80 PIO input to port A and DAC. The power supply consists of IC voltage regulator which compares and corrects the output voltage with the reference voltage supplied by IC 741. A Darlington transistor pair is used to boost the output current. Resistors R_1 to R_3 and preset P_3 to P_5 adjust the maximum output current and maximum output voltage. Port B controls the transistors TR_1 to TR_5 which switch the various resistors and potentiometers in the current and voltage ranges. TR_6 is used to switch the mode as CC or CV. The other transistors TR_7 and TR_8 are not used, but which may later be used for additional control function. The current regulator section uses 6 transistors (2N 3055) in parallel to increase the current output with the driver transistor in Darlington connection to minimise the loading of IC 741. The preset P_6 is used to trim the output to the full scale current of 5 amperes. The current regulation is software controlled, i.e. the voltage measured across the series resistance (0.10 Ω) is fed through the ADC section to the CPU which continuously monitors and corrects the drive for the regulator. Here the drift in current due to temperature rise of the transistors or change in voltage is almost zero.

PRELIMINARY CALIBRATION

Adjust P_1 such that U_{ref} is 10.000V. Next 'SET' data lines to logic zero level, the output of operational amplifier 741 should be zero, if not adjust the offset adjustment potentiometer P_2 to zero volts. Next 'SET' range switching transistors and adjust the corresponding potentiometers for full scale voltage of 30 V.

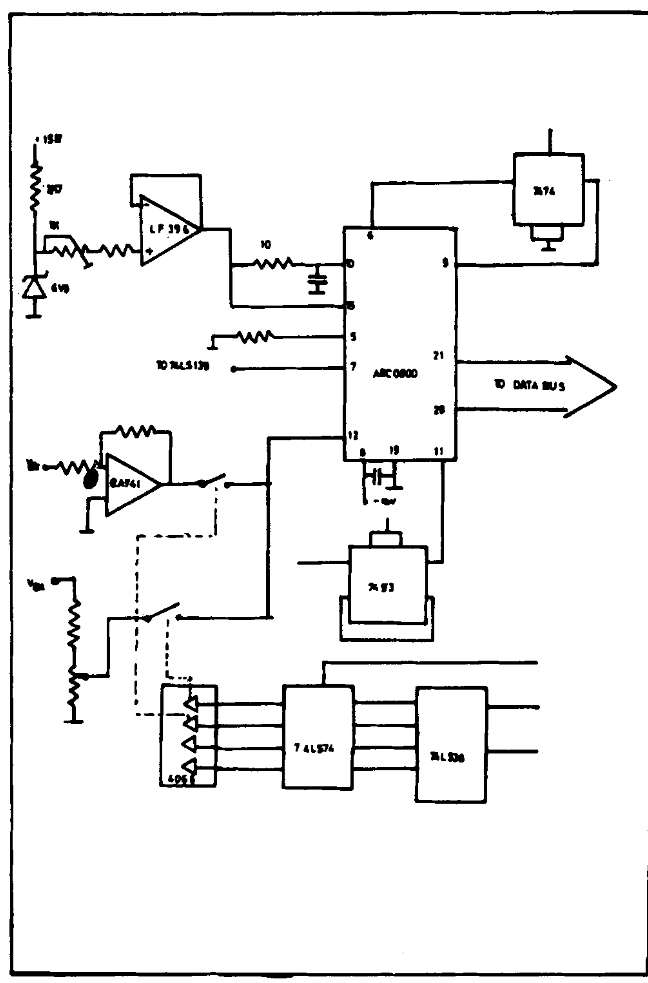

Fig.3: ADC board interface

ADC BOARD (Fig.3)

ADC 0800 is the heart of this section connected directly to the data bus since it has tristate output with an output enable pin.So, output enable OE is connected to port addresses 2y3 of 74LS139. The counter is operated in continuous conversion mode by tying the EOC (end of conversion) output to SC (stop conversion) input through a D flip flop between EOC (D input), and SC (Q output) to prevent oscillations during the first four clock periods. The voltage V_1 and V_2(V_2 being the drop proportional to current i across the resistor $R = 0.10\Omega$)are selected through quad bilateral switches (CD 4066 AO) to the V_{in} of ADC 0800. The function selector switches are latched through 74LS74 from address decoder 74LS138. The full scale adjustment range is done using V_{ref} adjustment to 5 V_{DC}, and zero adjustment using zero adjustment preset. Clock is taken from CPU clock through a divider chain 1/2 MM74C74 since maximum clock frequency is only 800 KHz for this ADC chip.

SYSTEM SOFTWARE DESCRIPTION

The software for three different types of charging is explained with the flowcharts shown in Figs 4,5,6, and 7.

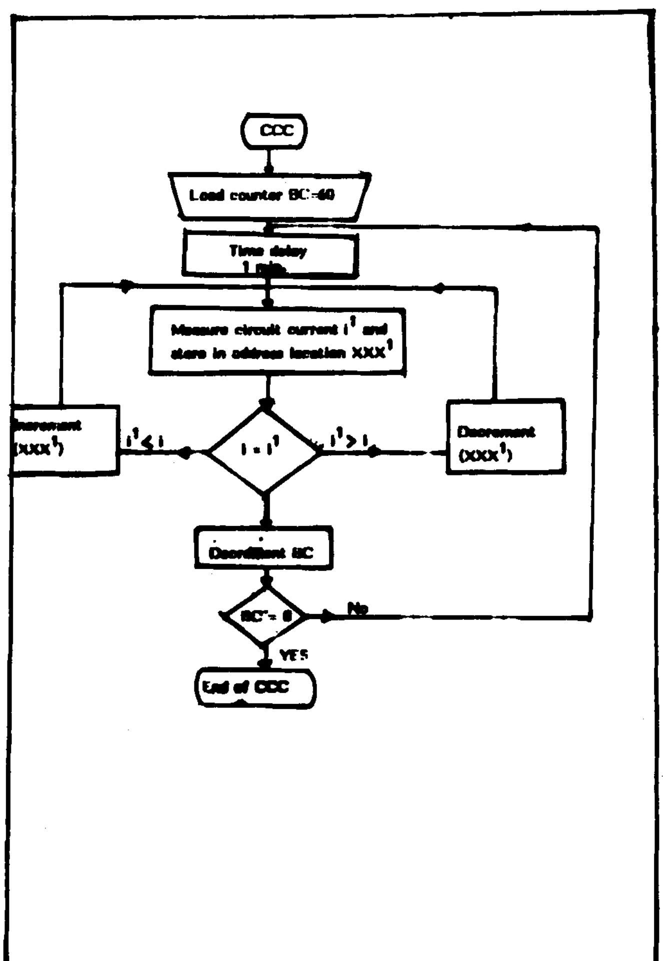

Fig. 4: Flowchart for constant current charging programme CCC

(I) The constant current charging (Figs. 4 & 5) involves hourly monitoring of battery voltage. As soon as three consecutive voltage readings are equal the charging is stopped.

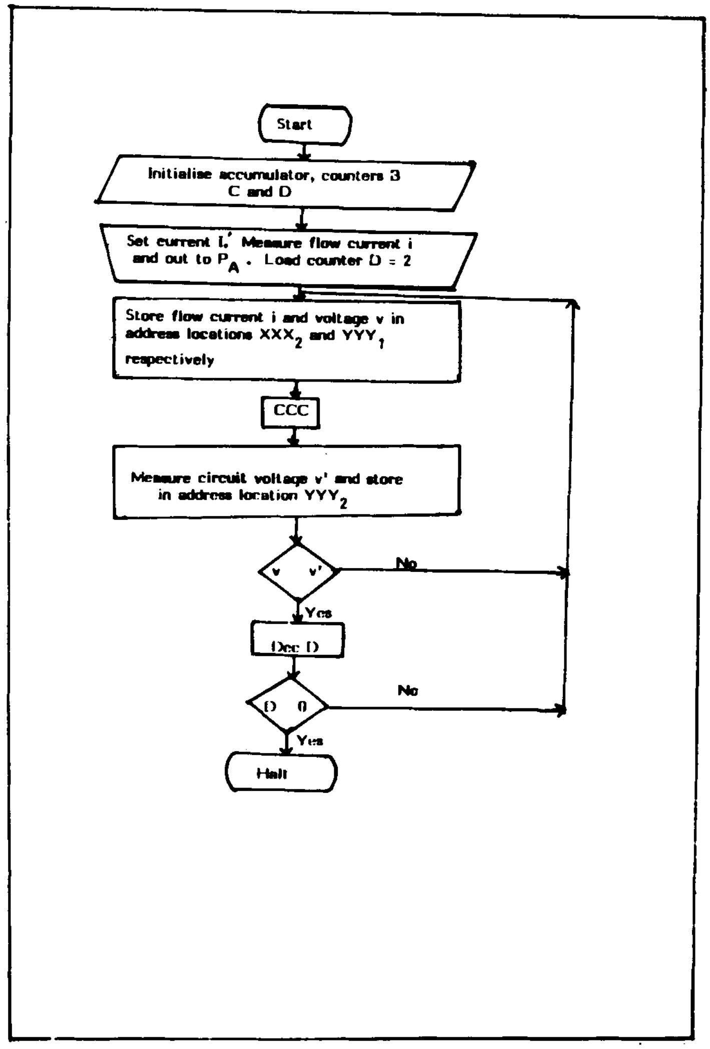

Fig. 5: Flowchart for constant current charging with automatic completion of charge

(II) The multistep constant current charging comprises of several durations with preselected current values.

(III) The pulsed charging in which the battery is charged under constant current (I), and the ON time (charge) is dependent on voltage, which is continuously monitored and when preselected voltage (V_1) is reached the charger is OFF for T_{off} duration and again charges the battery until V_2 is reached and cycle repeats. When V_n is reached the charging is stopped. This can be extended to full charging as in type I for three consecutive hours.

The software programming used for the above kinds of charging are described in detail in the following sections:

Type I

This incolves CC charging with a continuous check at hourly intervals to verify whether three consecutive voltage readings are same and if so to terminate charging. The binary word corresponding to the desired current value is stored in a memory location and output through P_A of PIO. The current flowing through the circuit and voltage at battery terminals are sensed by ADC and stored in separate memory locations XXX_2 and YYY_1 respectively. The register pairs BC operate as an hour counter in minutes. Every minute the current is compared with the prestored value; adjusted if necessary, and the contents of BC decremented. As the contents of BC register become zero, the voltage is measured and compared with the value at YYY_2 until the battery voltage becomes constant, the process continues. The contents of D register (which has been set to 2) is decremented, when voltage constancy is detected. This continues until D = 0. Finally the charging is stopped.

Type II

The charging method is as shown in Fig.6. First the digital binary word is output to port A of PIO corresponding to current I_1. The charging current is maintained constant as described in the flow chart. Here the contents of the register BC are decremented every minute so as to function as a minute counter. When BC = 0, an 8 bit word corresponding to current I_2 is set in memory location and output to DAC through P_A of PIO. Load DE = X_2 (time). Decrement DE every minute and when DE = 0 repeat the same process for I_3, I_4.,. I_n for T_1, T_2.,. T_n.

Type III

The charging is of CC type as described in flowchart. Load V_1 in XXX_1, V_2 in XXX_2... and V_n in XXX_n location. After the one

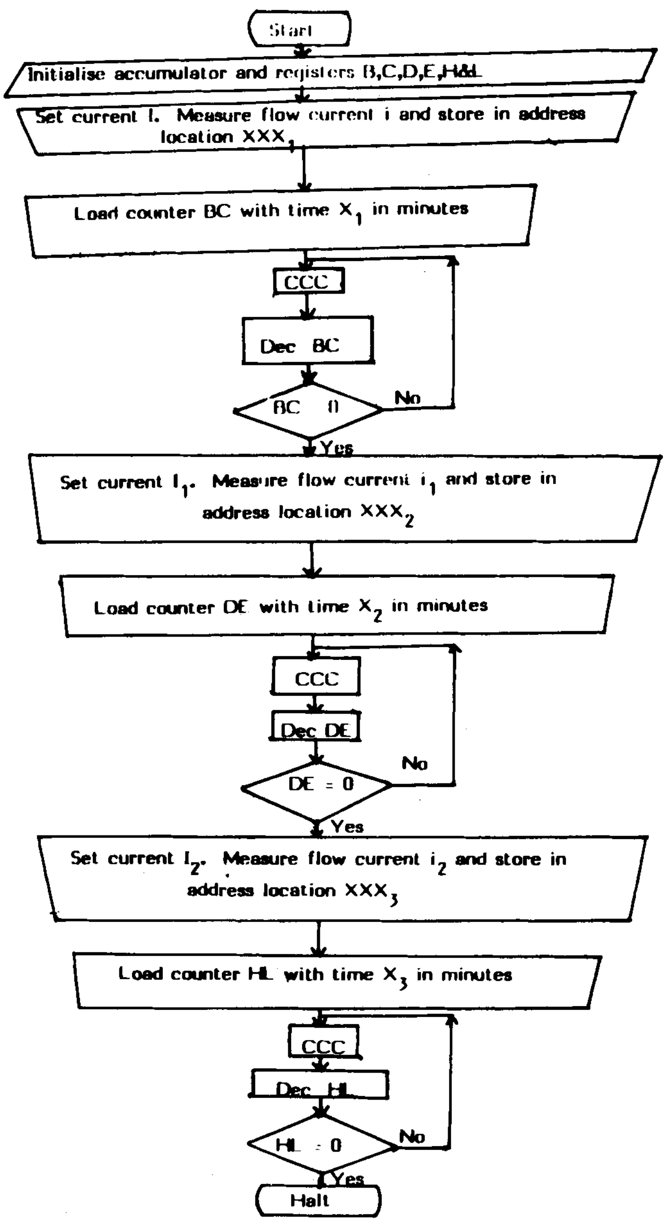

Fig.6: Flowchart for time controlled multistep charging

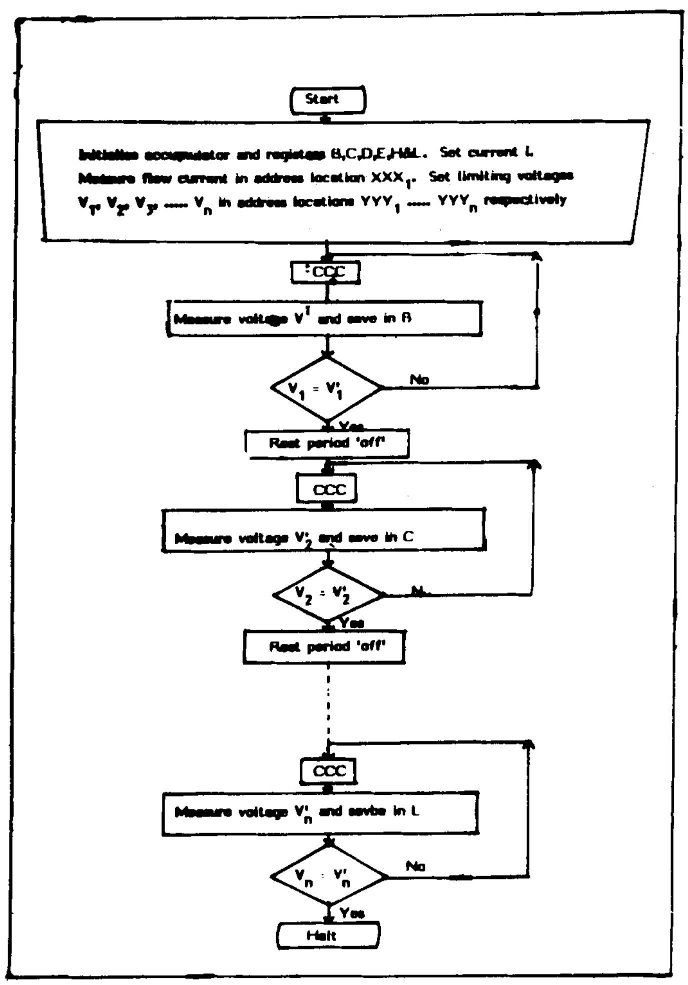

Fig.7: Flowchart for voltage controlled constant current charging

minute time loop is over, the voltage is measured and compared with V_1. If $V_1 = V'_1$ go to rest period loop and return to charge. After the one minte time delay loop, the voltage is measured V'_2 and compared with V_2. If $V_2 = V'_2$ go to rest period and return to charge repeat cycle. If $V_2 = V'_2$ continue charging. Here it should be noted that charger 'OFF' time is constant irrespective of measured voltage, and only the charger ON time is dependent on the voltage i.e. $T_{ON} \propto V$ (measured voltage).

CONCLUSION

Though only three types of charging are described here, other types of charging methods (e.g. in multistep constant current charging every step can be made voltage dependent) can be performed.

REFERENCES

(1) Fred Benjamin, *System for 20-min recharging of sealed nickel-cadmium batteries,* Society of Motion Picture and Television Engineers, April 1977, Volume 86.