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ELECTROCHEMICAL INSTRUMENTATION

A VERSATILE TEST SYSTEM FOR LEAD ACID BATTERIES

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ABSTRACT

The paper describes a versatile instrument system for evaluation of life cycle test of various types of lead acid batteries. It consists of a master time and function control using WD 55 microprocessor based timer chip that precisely controls discharge and charge sequences within preset durations. The system has constant current load banks both for charge and discharge circuit. The versatility of the system consists in the adoption of the unit for testing life cycle of any type of battery (with varying life cylce test procedures) and for independent charging or capacity test of the cells.

Key Words: Lead acid battery life cycle test, charging and capacity test

INTRODUCTION

Lead acid batteries continue to dominate the storage battery scene, in spite of repeated predictions of imminent doom. In India, the present level of production of batteries is about 23 lakhs per annum and at the end of Seventh Plan perid, the production may touch about 35 lakhs. With increased thrust on solar power for small village communities, the application for this system as a composite power package, with solar cell is enormous. Other possible applications such as energy storage and electric vehicles, can still further boost the demand pattern. Small scale sector contributes considerably, in battery production (about 15 to 20%). The input in terms of precious nonferrous metal (lead) going into the production is large. Under these circumstances, it becomes imperative that emphasis be laid on the quality of the product to satisfy the Indian working conditions. In this context testing and evaluation of batteries assumes great importance.

While in the organised sector, testing facility is available to some extent, in the small scale sector it is either woefully inadequate or non-existent. Laboratories like CECRI and some other organisations like National Test House, ISI, CIL, etc. provide test facility. However, in view of the diversity in the types of batteries, applications and test procedures, it is increasingly appropriate that basic test facilities should become a part of all manufacturing centres.

For batteries, important types of tests are essentially; the same, such as capacity test, life cycle test, endurance test, retention of charge test, etc. but the specification of test voltage, current, duration, etc. vary for different types of applications. So, test euipments available in the market, whether indigenous or imported are custom built catering to individual test specifications like capacity tester, life tester, etc. There is a dire need for a test system which enables several types of tests to be performed, on a variety of batteries, with minor modifications.

The present communication describes a semi-automatic system, that can be adapted for testing different types of batteries. The emphasis is mainly on testing of lead acid batteries of various types, such as automotive (SLI), stationary etc. Modular design has been done, so that only the charge/discharge unit has to be changed to suit the different current and voltage requirement. The prototype designed can test one battery at a time, but can be extended to any number of batteries by multiplying the charge/discharge unit and with the same timing sequence.

SYSTEM DESCRIPTION

The system is presented in the schematic block digram (Fig.1). The charge/

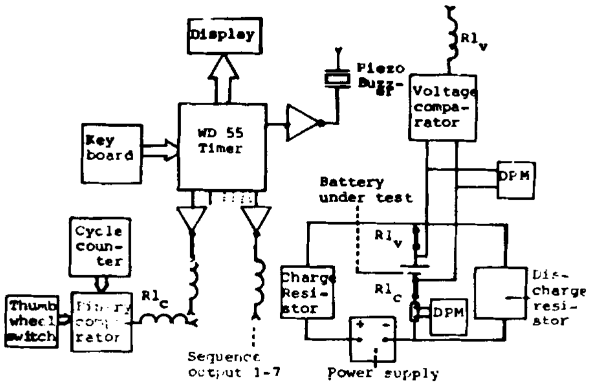

Fig.1 Block diagram of the battery test system

discharge process in battery testing is carried out through electronic DC resistors for constant current control. The charge or discharge resistor is controlled by the relay RL_1, through RL_7 contacts which are energised by the programmable timer. The timer based on WD55 IC chip (Western Digital Corporation, USA) is used as a sequencer. However, cyclic operation is also possible. For cyclic operation external diode strap or thumbwheel switches are required for data storage. In sequential mode of operation the on chip RAM is used for data storage and a four digit seven segments display for data recall.

The voltage comparator during discharge senses the battery voltage, compares with a reference and energises the relay RL_V. It cuts off the battery from the circuit, if the battery voltage falls below the present limit. For capacity test, the timer itself is used as a time counter (up counter.) The relay contacts RL_1 through RL_7 can be shunted by switches, so that, the test can be carried out manually. The above relay contacts are connected in series with individual switches. By proper selection of switches the relay output is made to control charge or discharge resistor. The relay output of the timer after contact bounce elimination and pulse shaping, forms the clock pulse for cycle counter. The cycle comparator, cuts off battery from cycling when desired number of cycles are completed, as preset using thumbwheel switches. The details of each sub-system is described below.

FUNCTIONAL DESCRIPTION

The system functionally consists of timer, control circuit and charge/discharge unit.

Timer

The Timer WD55 chip is a versatile self-contained digital timer/controller/sequencer designed to replace many of the control functions currently being performed by gears, cams, levers and motors, etc. It is a 4 bit P. channel silicon gate MOS preprogrammed, microprocessor based, microcontrolller.

The WD55 is used in conjunction with matrix keyboard (4 × 4 matrix), and 4 digit, 7 segment display to indicate the time and the sequence number. The timer functions are preprogrammed with MASKROM with different feautures determined by external strap options. The key functions and strap options are described below.

Keyboard

A standard 4 × 4 matrix keyboard of the electromechanical type with audible feedback through the alarm output can be used. The matrix diagram is shown in Fig.2. It should be noted that switch across (i) D through D3 and IN3 (ii) D7 and INI through IN3 are outboard type (push button etc.) for data storage. The functions of each key is as follows.

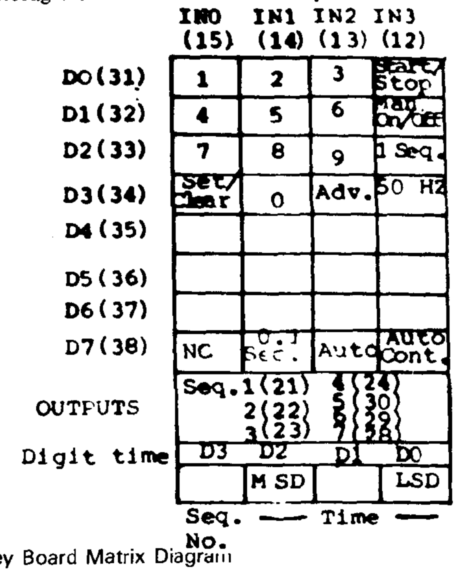

Fig. 2. Key Board Matrix Diagram

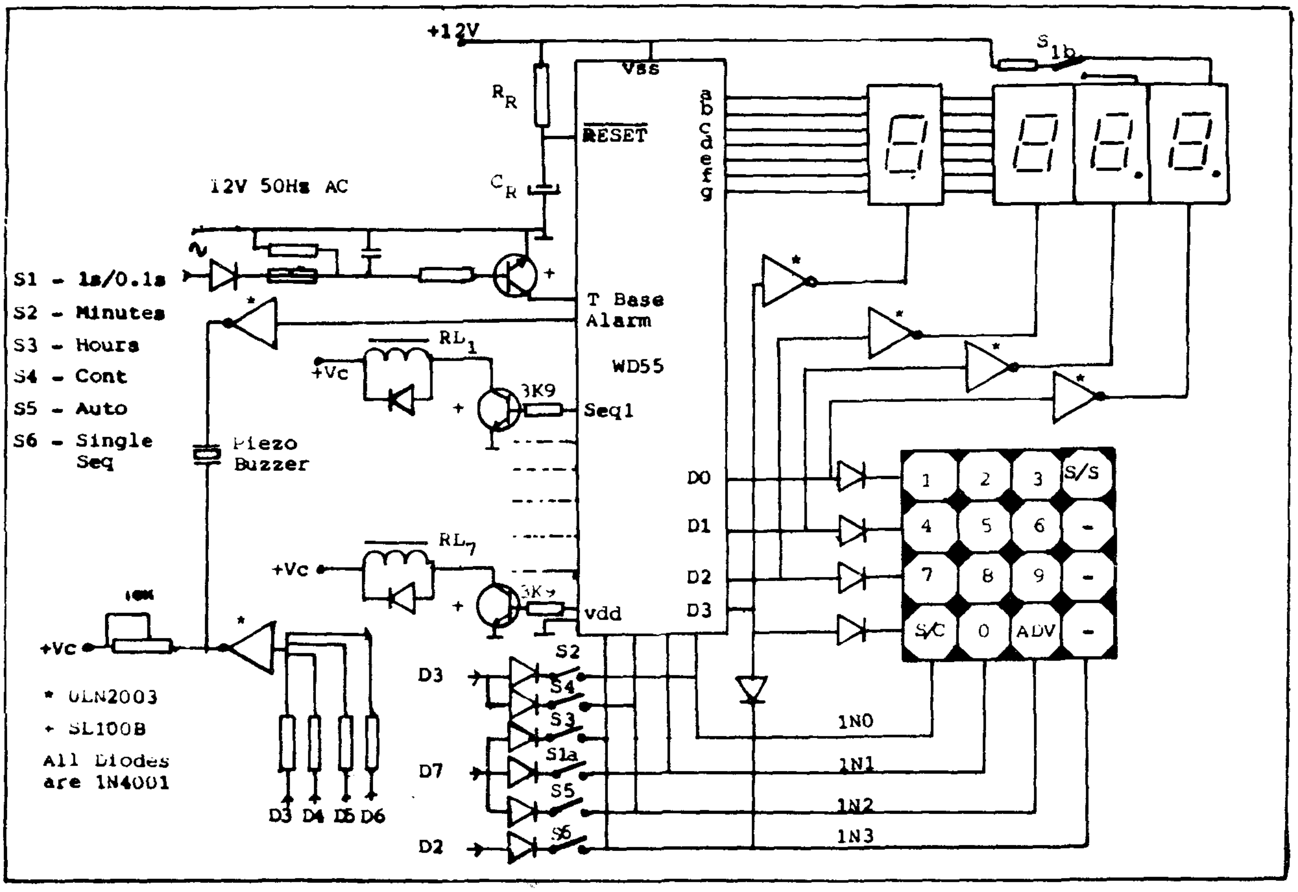

Fig. 3. Timer Module

Keyboard functions

Advance

The key is used to access seven storage locations in RAM when used as 7 sequence controller. Each time this key is depressed, sequence number is incremented by one, and the current value of respective sequence time is fetched and displayed in 3 digit display device. There is no separate enter or store programme, since data entered, is automatically stored. The keys numbered 0 - 9 are used to enter numeric data, in 'SET' mode. Data entry is accomplished by right to left entry that is digit 0 to 2 are left shifted by one digit (with old values of digit 2 discarded.) If the SET/CLEAR key has not been previously depressed, before entering data, these keys are ignored.

WD55 has strap options in the form of anodes to select or delete specific functions which makes it versatile.

Single SEQ

This strap forces the device to operate on 'one' time available. The SEQ digit does not advance at the end of the timed sequence.

0.1 Sec strap

The basic resolution of 1 sec is divided by 10, i.e. intervals of 0 to 99.9 secs. are possible.

Auto strap

The sequence one through seven are executed without further intervention. The cylce stops at the conclusion of sequence 'seven' and sequence 'one' data is displayed.

Auto-cont strap

This is used in conjunction with auto strap. Here at the end of SEQ7, the SEQ1, straps automatically. The strap must be connected through a switch, since there is no means of terminating the sequence once initiated. The START/STOP key when depressed will only terminate the current sequence in progress and begin execution of the next, when stop key is released.

The minutes strap, when connected, data is evaluated as minutes, likewise when hours strap is connected data is evaluated as hours. Next we shall briefly describe the timer circuit (Fig 3).

All the sequences output SEQ1 through SEQ7 are buffered with a transistor inverter to drive the relay to control charge/discharge and other circuits.

A high valued electrolytic capacitor is connected in the control module across supply line and ground. Similarly all the I.C.s are decoupled, with 100 nF polystyrene capacitor. This ensures the data stored in RAM and also prevents malfunctioning of the circuit due to relay switching transients. The resistor R_2 and capacitor C_R ensure that display is automatically reset to '1000' when supply voltage is switched on.

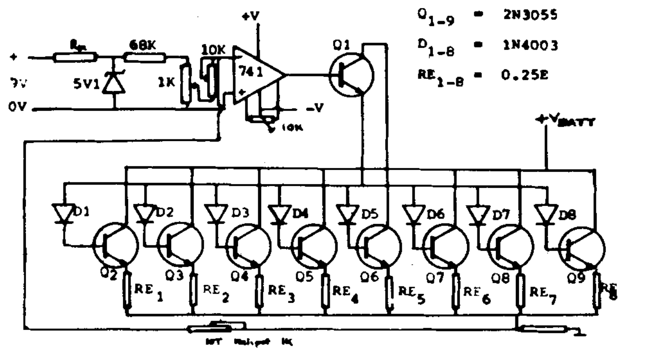

Fig.4. Constant current controller module

Electronic current controller (D.C resistor)

The constant current control in charge or discharge circuit is accomplished by using transistors (Fig.4).

A constant base bias to a transistor in common emitter configuration with current feedback arrangement using op.amp. 741 keeps the collector current constant irrespective of collector to emitter voltage (VCE) change in the active region.

The constant base bias is established by VR_1, IC and the potentiometer P_1, which is a 10 turn helical potentiometer with calibrated dial to indicate the current. The emitter resistances RE_1 to RE_8 make the emitter current to a safe level and also compensate for variation in transistor characteristics. In our circuit, we have used the same type of transistor (2N3055) in parallel to increase the current handling capability, so we have used equal value of emitter resistance.

Switching circuit

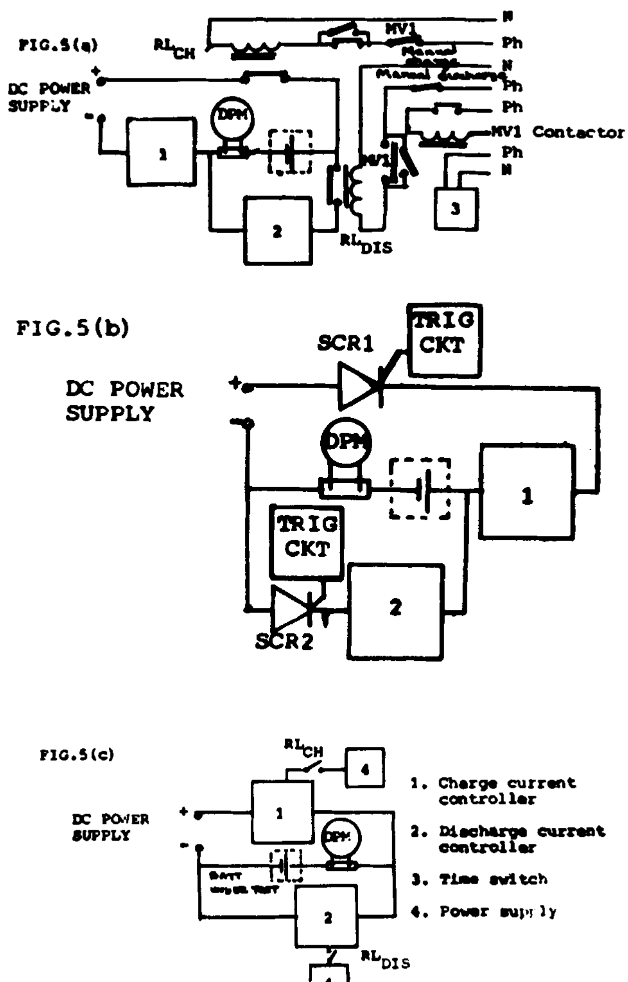

Fig.5. Switching circuit (a) Electro mechanical contractor circuit
(b) SCR switching circuit
(c) Direct switching circuit

The Fig.5 (a,b,c) shows various methods of switching the charge/discharge circuit. It can be seen that each has its advantage and disadvantage. The preferred one is shown in Fig.5(c), which is simple and economical, though it has a drawback, viz. at zero base current a small leakage current flows in the collector circuit (ICEO) of the order of 0.1 to 0.2 μA which is insignificant as far as lead acid battery is concerned.

Cycle counter

The Fig.6 shows the 3 digit decade counter. The counter output is latched

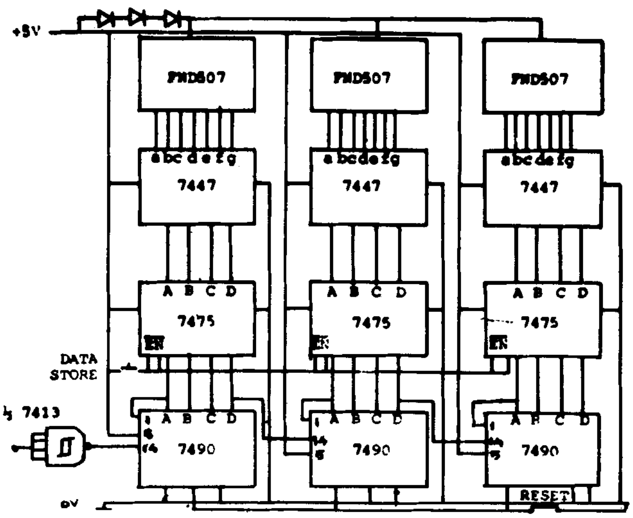

Fig.6. Cycle counter module

using 7475 flip flop, for storing the data from the back up battery in the event of power failure. The 7447 decoder drives the (FND507) 7 segment LED display. The clock input is fed through a quad input schmitt trigger (7414) for pulse shaping.

Cycle comparator

This is presented in Fig.7. The Binary Coded Decimal (BCD) output of

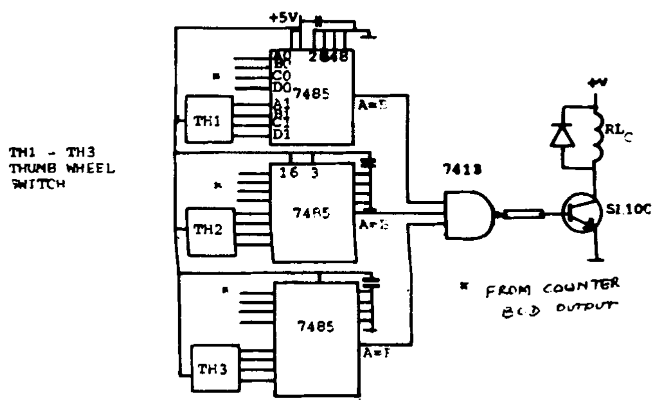

Fig. 7. Cycle comparator module (P.C.I.)

the cycle counter (i.e. output of 7475) and the thumbweel switch output data are compared using the 7485. It is a 4-bit magnitude comparator. The cascade pin A = B is tied to + VCC and other pins are grounded. The A = B output of the 3 comparator are high, when the 4 bit B.C.D. data $A_1 = A_2$; $B_1 = B_2$; $C_1 = C_2$; $D_1 = D_2$; condition is satisfied. The output of the three comparator is fed into a Triple input (7411) AND gate, the output of which is buffered through transistor inverter, driving the relay. The relay cut off the battery under test after present number of cycle is completed.

VOLTAGE COMPARATOR

The regulated (Fig.8) supply, after voltage dividing through dividing

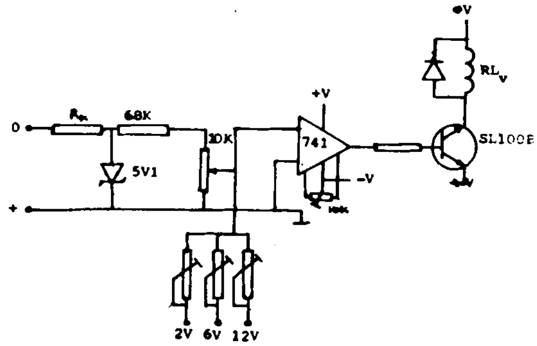

Fig.8. Voltage comparator module

network, forms the reference voltage for the 741 voltage comparator. So when the battery voltage falls below the preset reference voltage, the relay is energised and cuts off the discharge circuit.

APPLICATION OF THE SYSTEM

From the chart (Table I), it is seen that life cycle test procedures vary both in terms of the sequence and electrical test parameters. While test procedures relating to automobile and motor cycle batteries are similar and resemble cyclic endurance test IEC 95-1(1980) in essential details, the life cycle test of stationary, traction cell, etc. come under one class. The SAE tests on the other hand are different.

With the present system, however, it is possible to accommodate any of the test sequences subject to proper selection of charge/discharge modules and separate control test unit (whenever high rate discharge is specified).

Operation procedure using the new system is presented for testing a battery as per IS 7372.

Key board operations

1. Hour strap ON
2. Normal/auto to auto position
3. Autocontinuous ON
4. 0.1 sec/1 sec to 1 sec position
5. Normal/single to normal position

The settings are made for relay output (Table II).

Table I: Life cycle test prodecure

S. No.	Specification	Type of battery	Life sequence	Control test
1.	IS 7372	Automobile batteries	a. Disch 1 hr $I = 0.1\ C_{20}$ Charge 5 hrs $I = 0.1\ C_{20}$ Cycle upto 36 cycles b. OC 96 hrs c. HRD test d. Recharge e. Go to (a) f. Total 3 times	HRD test
2.	IS 1651 RDSO	Stationary batteries	a. Disch 4½ hrs $I = 0.17\ C_{10}$ b. Charge 7½ hrs $I = 0.12\ C_{10}$ c. C_{10} at 50 cycles	C_{10} at every 50th
3.	IS 1145	Motor cycle batteries	a. Disch 1 hr. $0.1\ C_{20}$ Charge 5 hr. $0.1\ C_{20}$ Cycle upto 36 cycles b. OC 96 hrs c. HRD or C_{20} test d. Recharge e. Go to (a) f. Total 3 times	HRD or C_{20} test
4.	IS 5154	Traction cell	a. Disch 3 hrs $I = 0.25\ C_5$ Charge 9 hrs $I = 0.096\ C_5$ Cycle upto 50 cycles b. C_5 test c. Charge d. Go to (a)	C_5 test

The cycling will be repeated and is indicated in the cycle counter. 'SET' thumbwheel switch at 036 cycles so that life cycle terminates at 36 cycles indicated by audio/visual alarm. Now the control test is manually initiated after 96 hours open circuit can be set in the normal mode. The battery is charged manually after test and cycling started as described above for the next unit.

The same type of operating scheme can be set up for other life cycle test procedures.

Table II: Key board operation settings for relay output

SEQ	Operation	Keys	Display		Relay Switch
			Seq	Time set	
1	Disch	Clear	1	000	Disch.
		001	1	001	
2	Charge	Advance	2	000	
		Clear	2	000	Charge
		005	2	005	
	Repeat upto 5th sequence in this order				
6	Charge	Advance	6	000	Charge
		Clear	6	000	
		004	6	004	
7	Charge	Advance	7	000	Charge
		Clear	7	000	
		001	7	001	

CONCLUSION

The test system as described above can satisfy the requirements of several types of batteries — automobile or stationary cells. However when the desired test is restricted to only one of the types the instrument will be simple.

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