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ELECTROCHEMICAL INSTRUMENTATION

MICROPROCESSOR BASED ELECTROCHEMICAL PROTECTION SET UP

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ABSTRACT

The design details of an automated multielectrochemical protection set up for laboratory study is described. For trial run, four bare mild steel cyclindrical tanks of 0.6 m diameter and 0.9 m height of approximately 25 m^2 surface area containing 3% NaCl solution were put under test for two months. The system is found to work satisfactorily. The set up uses an 8085 microprocessor with its associated hardware chips, battery back up unit, power controlling circuits, announciator and calomel electrodes for sensing the potentials. The details on the design of the equipment are presented.

Key Words: Electrochemical protection, impressed current, microprocessor

INTRODUCTION

Various non-automatic and automatic devices are used in providing suitable corrosion protection to the metals in service. Some involve active circuits and some passive circuits like sacrificial anodes etc. In active control, controls involving various level of technological developments have been reported. They are (i) rectifier and auto-transformer control in non-automatic modes and (ii) motor operated variac, magnetic amplifier control, transistorised potentiostat, silicon controlled rectifier control, microprocessor/microcomputer based system control in automatic modes.

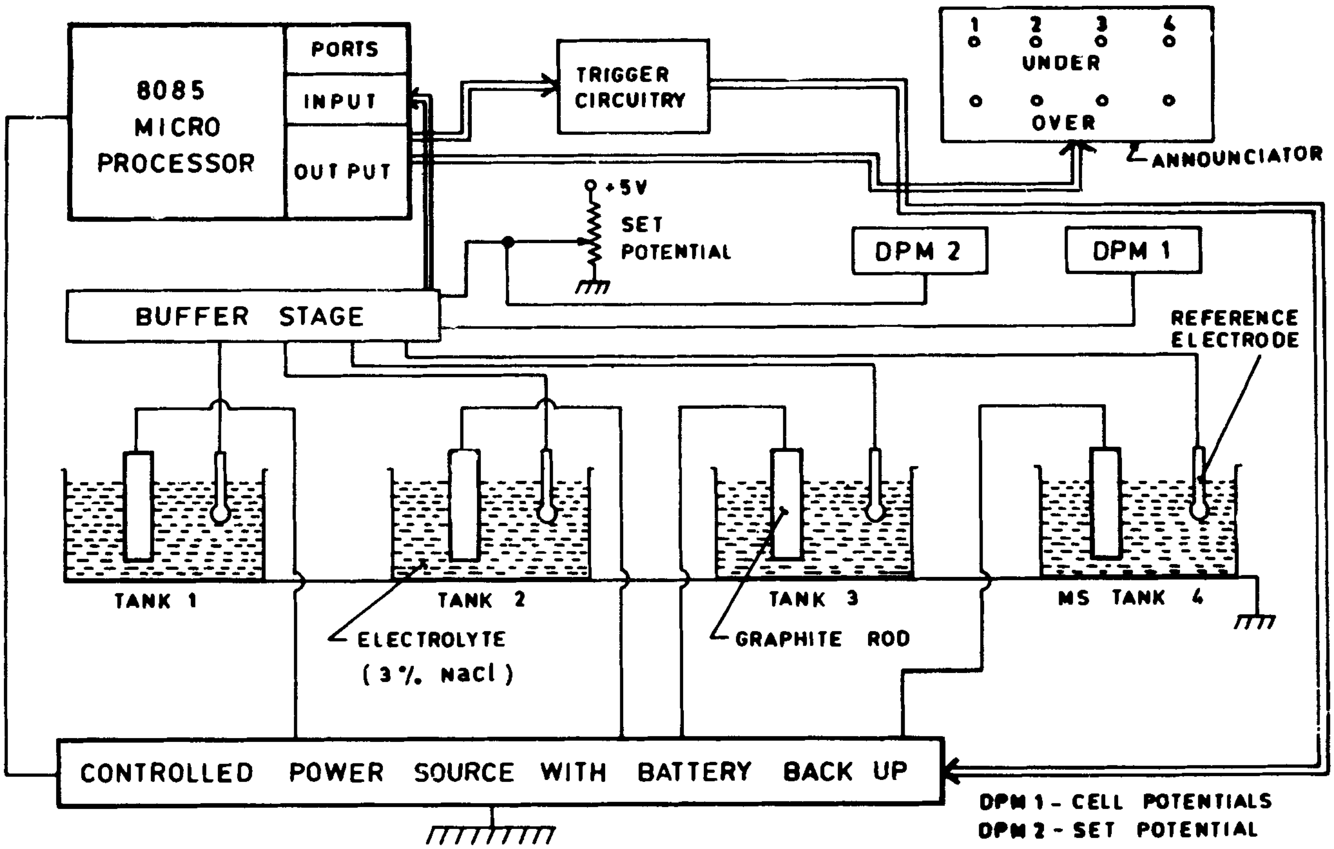

Fig.1 Layout of the Microprocessor controlled E.C. Protection System

Various modern developments have taken place in view of the availability of modern electronic gadgets at a lower cost and the flexibility of introducing such systems with visual recording and announciating units at the users' site for monitoring. In this laboratory, industrial type potentiostat using SCRs for electrochemical protection has been developed and tested for use. In continuation, a multielectrochemical protection set up (M-ECPS) using microprocessor has been developed and tested for use.

INSTRUMENT DESCRIPTION

The design of the system is centered around an eight bit microprocessor unit and a programmable power supply unit. The system is designed initially for protecting four electrochemical systems even though it is capable of protecting 255 such systems. Two digital panel meters (DPM) are provided in the unit which are used to set the desired protection potential and to monitor the various cell potentials. To be an user friendly system, to indicate the status of each cell and its components an announciator is incorporated. The tested system consists of four bare mild steel cylindrical tanks of 0.6 m diameter and 0.9 m height of approximately 25 m^2 surface area containing 3% NaCl solution. Saturated calomel electrodes (SCE) are used to sense the half-cell potential of the ECS. Batter back up for memory has been provided to take care of power interruption.

PRINCIPLE OF OPERATION

The lay out of ECPS is shown in fig. 1. Microprocessor Intel 8085 is used to sense the half cell potential and control the flow of current through the appropriate tanks. The level of electrochemical protection is sensed by the reference electrode in the form of voltage signal and is fed to the buffer stage for processing. The processed signal is fed into microprocessor for logical decision. Appropriate control signals are issued to trigger circuitry to get the desired output level from programmed power source to the individual units so as to maintain the tank in the protection range. Additional software is introduced to analyse the data from buffer stage for announciating any system default like (i) sensing electrodes becoming non-operational (ii) feeding electrode at anode getting open ciruited etc. and to give appropriate warning optical light outputs.

INSTRUMENT OPERATION

The entire sequence of operation is controlled by the developed software stored in memory. Activating the execute button, the unit becomes operational, once we have connected the system as shown in the layout. Before energising, the following prerequisites have to be carried out. The required protection potential is set using digital panel meter (2) and the number of tanks

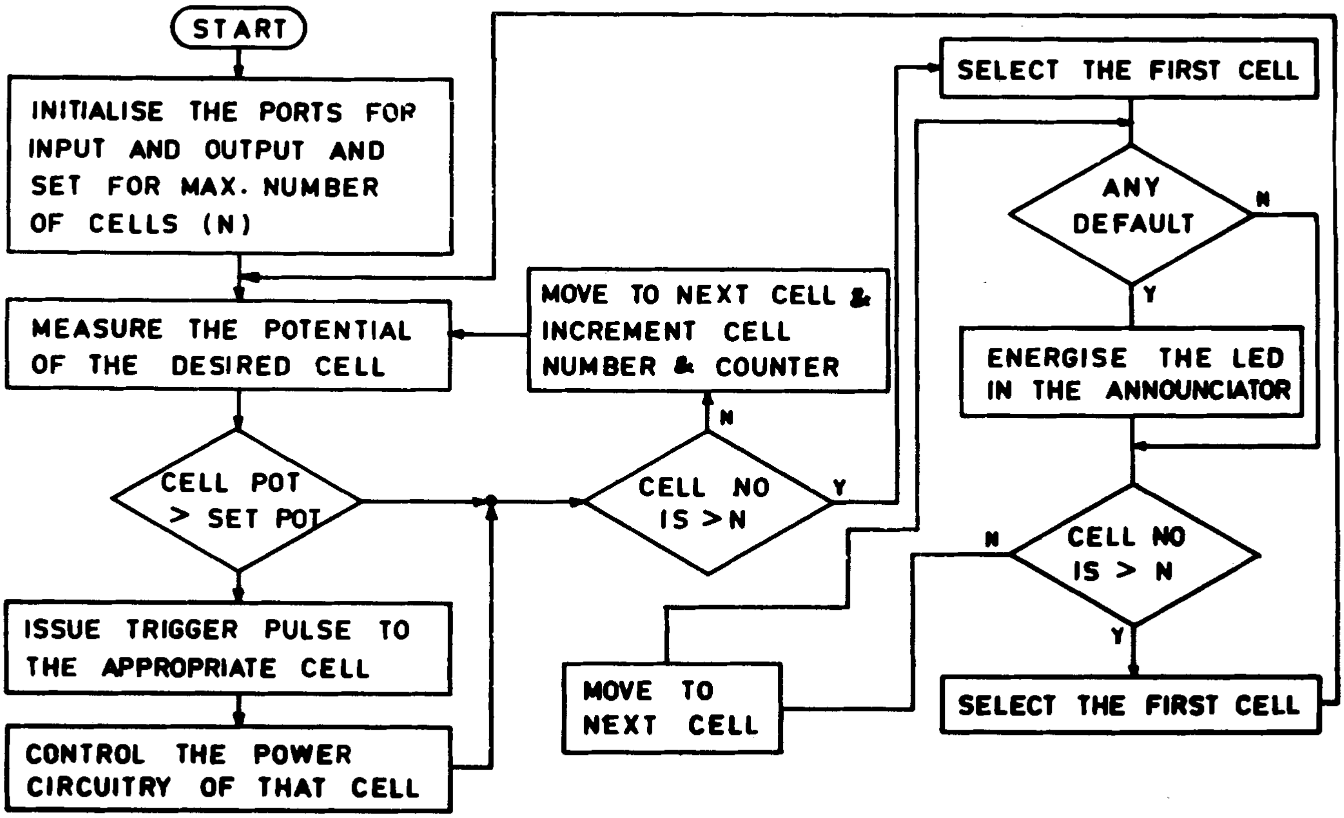

Fig. 2 : Flow Chart

to be protected is keyed in (here N = 4) at memory location 2080. The sequence of operation is shown in the flow chart (Fig.2) Executing it, the unit goes into cyclic operation. The potential from the first sensor is compared with the preset protection potential (-820 mV). If it is greater than the set value it goes to the next cell and carries out similar comparison. If it is less than the set value, trigger signal to switch on the power supply to the appropriate cell is applied. After that, it moves to the next cell. Each time before moving to the next cell, the maximum programmed number is checked in whereby either it goes to the next consecutive cell number or back to the first cell depending on the comparison logic.

After a sequence of monitoring of all cells, the operational path moves to annunciator software. Here the signal from buffer stage is compared for overprotection and underprotection for each cell. Depending on that, corresponding LED will be lighted for warning. After that it moves back to the original cycle.

Thus the cycle of operation goes on to maintain each cell at the desired protection potential.

RESULTS

The initial potentials of tanks were individually measured and are given in Table - I. Initial polarisation current was in the order of one ampere

Table I: Test results : Initial potential (with respect to SCE) mV

Tank 1	Tank 2	Tank 3	Tank 4
− 625	− 640	− 680	− 640

and the tanks were polarised for 12 hours at a current density of about 40 mA/m^2 to maintain at about -850 mV with respect to SCE. Later the tanks were connected in parallel to the microprocessor circuit for automatic control of potentials. The unit is tested continuously for the last six months. The results are shown in Table II. It could be seen that the unit is able to maintain the potential efficiently within ± 10 mV precision.

Table II: Potential vs time

Set potential : − 830 mV

	Tank 1		Tank 2		Tank 3		Tank 4	
Sl.	Potential mV	Current mA	Potential mV	Current mA	Potential mV	Current mA	Potential mV	Current mA
1.	− 820	120	− 828	100	− 830	70	− 827	95
2.	− 822	113	− 829	95	− 831	70	− 829	85
3.	− 825	115	− 830	70	− 832	65	− 828	75
4.	− 830	90	− 830	75	− 831	70	− 830	75
5.	− 831	85	− 831	70	− 832	60	− 832	70
6.	− 832	75	− 832	70	− 831	60	− 831	70
7.	− 834	60	− 830	65	− 834	50	− 833	65
8.	− 830	70	− 834	30	− 832	60	− 828	55
9.	− 832	65	− 832	40	− 833	60	− 830	60
10.	− 831	60	− 832	50	− 834	50	− 810	40
11.	− 832	55	− 830	45	− 833	55	− 834	30
12.	− 833	55	− 828	50	− 832	55	− 830	15
13.	− 834	50	− 830	40	− 834	45	− 832	40
14.	− 832	55	− 833	40	− 832	55	− 834	30
15.	− 834	50	− 834	30	− 831	60	− 829	50

To summarise, the salient features of the designed equipment are:

1. Number of channels	:	1 to 255
2. Range of protection	:	+ 2 volts to -2 volts (flexible)
3. Type of protection	:	Anodic and/or cathodic
4. Power supply	:	Can be isolated or interconnected (4 Nos. of 10 volts, 250 mA unit)
5. Outputs	:	(i) Desired tank potential can be seen using band switch and 3½ digit DPM
		(ii) Separate current meters
		(iii) announciator with LED outputs for each tank to indicate over-or underprotection

CONCLUSIONS

The main advantages of the circuit are:

1. Centralised control is made possible thereby avoiding monitoring of potentials at each user end.

2. Software flexibility to upgrade or modify design is easy to introduce.

3. Data logging for performance history is possbile.

4. Cost of control units of multiple individual system is many orders of magnitude in comparison withl this microprocessor based multiprotection system.

5. Combination of anodic and cathodic production systems can also be monitored to the same degree of accuracy.

6. Systems being defective due to opening of circuit either on the impressed current side or on the reference measuring side can be announciated.

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