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FABRICATION OF A LOW COST DIGITAL mV/pH METER

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A digital mV/pH meter based on the use of a commercially available CMOS 3½ digit A-D converter is introduced. The meter features automatic zero and off-balance search. The range coverage is 0-2000 mV, with an accuracy of ± 1 mV, full-scale. The unit is energised with a ± 5 V power supply operatable on 220 VAC, 50 Hz mains line. Output noise is typically less than 10 μV at a power consumption of 15 mW. The unit is directly adoptable for direct pH measurements.

Key words: Millivolt/pH meter, low cost potentiometry, digital pH meter.

INTRODUCTION

The measurement of potential difference in electro-analytical systems of varied nature is an important aspect of electro-chemistry. This is specifically true about pH measurements involving the use of glass and calomel electrodes. With the advent of modern electronic circuits employing precise components potentiometric measurements are now possible with a high degree of accuracy. Description of a couple of such circuits may be seen in literature [1,2]. During the last five years, electronic components, both active and passive, have gone through a process of tremendous improvement in terms of their fabrication and performance. Digital versions of mV/pH meters have rapidly replaced the op-amp based counterparts. Currently use has been made of MOS/FET op-amp circuitry for high-input impedance potentio-metric measurements. The commercially available ICL 7106 utilizes a liquid crystal display and the relevant circuitry is powered by 9V battery, with provision of DVM adoptation at the output [3]. Other workers have reported the use of IC741 in high impedance potentiometric circuits [4,5].

This paper describes the fabrication of a low-cost digital millivoltmeter/pH meter. The electronic circuitry, as shown in Fig. 1(A), is based on the use of a commercially available (Intersil, 7107, ICL system, USA) CMOS, 3½ digit A-D converter containing active devices on a single monolithic IC. The circuit detailed in the figure drives an LED display with auto-polarity and overload search. Details on pin connections of LEDs and ICL 7107 are given in Fig.

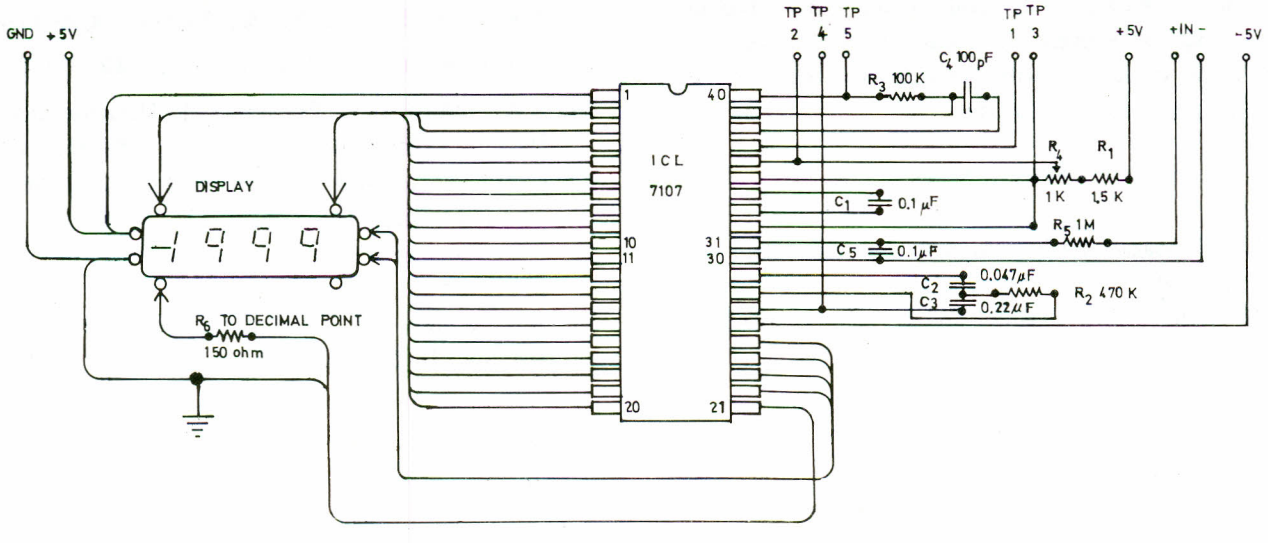

Fig.1(A). The circuit diagram of mV/pH meter.

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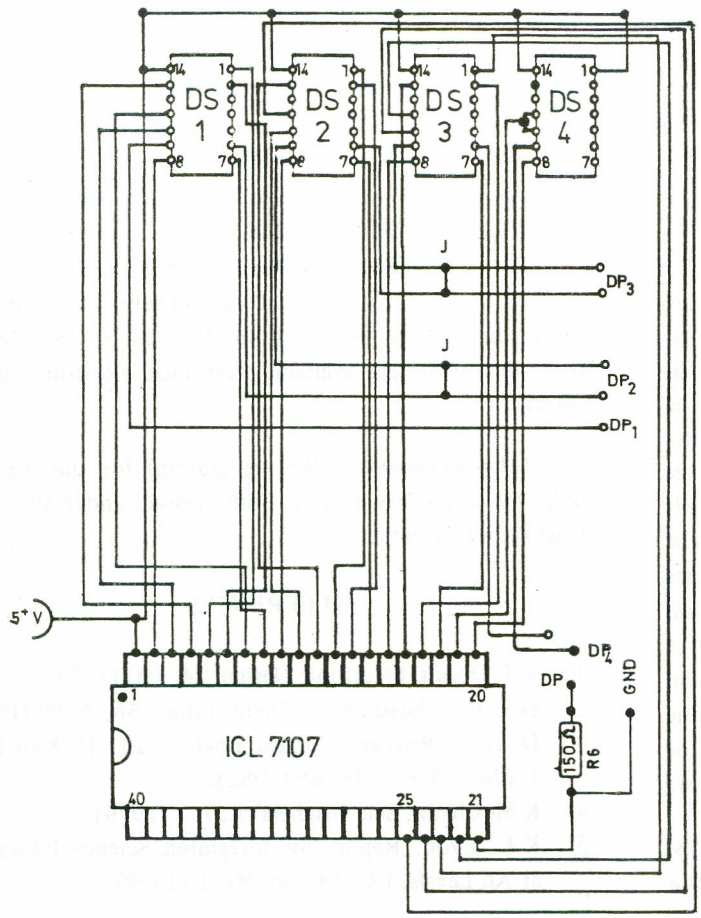

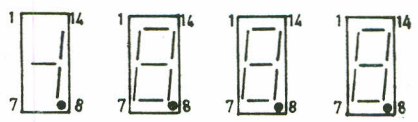

PIN CONNECTIONS (TOP VIEW)

1	CATHODE a	14	ANODE
2	CATHODE f	13	CATHODE b
3	ANODE	12	NO PIN
4	NO PIN	11	CATHODE g
5	NO PIN	10	CATHODE c
6	CATHODE d.p.	9	NO CONNECTION
7	CATHODE e	8	CATHODE d

PIN CONFIGURATION FOR LED 7107

1	SUPPLY (+)	40	OSC. 1
2	D (UNITS)	39	OSC. 2
3	C (UNITS)	38	OSC. 3
4	B (UNITS)	37	TEST
5	A (UNITS)	36	+ REF.
6	F (UNITS)	35	- REF.
7	G (UNITS)	34	+ REF. CAP.
8	E (UNITS)	33	- REF. CAP.
9	D TENS	32	COMMON
10	C TENS	31	INPUT HI
11	B TENS	30	INPUT LO
12	A TENS	29	AUTO-ZERO
13	F TENS	28	BUFFER
14	E TENS	27	INTEGRATOR
15	D (100'S)	26	(-) SUPPLY
16	B (100'S)	25	G TENS
17	F (100'S)	24	C (100'S)
18	E (100'S)	23	A (100'S)
19	AB (1000)	22	G (100'S)
20	POLARITY (MINUS)	21	DIGITAL GND

Fig. 1(B). LED wire connections (bottom view).

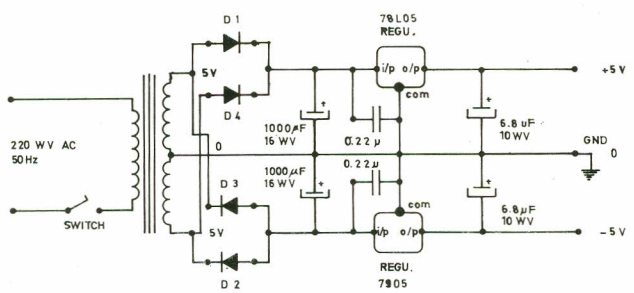

Fig. 2. The power supply.

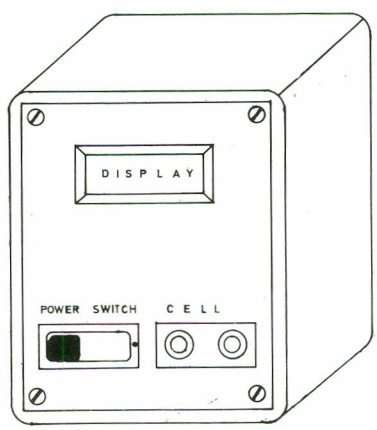

Fig. 3. The finished mV/pH meter.

1(B). Although ICL 7106 has a slight edge over ICL 7107 used in this work, yet the latter device does possess certain distinct advantages, one of these being its easy availablity in local market. Also, details on erecting the circuit and the pin connections are available with each device enabling the experimenter to construct his own unit without difficulty.

Design and function characteristics. The circuit is energised by ± 5V power supply shown in Fig. 2. The current demand by the LED display used is normally large in comparison to common intergrated circuits. Hence, a stable noise-free supply is a prerequisite for such circuits. The noise in the present power supply was effectively reduced with a 6.5 μF capacitor put to ground at the point where the supply entered the circuit.

Functioning of the mV/pH meter requires the following preliminary tests. With power on, and the input terminals shorted, the display reads zero. The proper function-

ing of the auto-zero system is indicated by a -0000 display for most of the time. The polarity in actual measurements, however, is indicated like this: negative by -, positive by +. The output display needs no check as to accuracy against a digital millivoltmeter as output accuracy range is 1999± 1mV full scale and has thus an accuracy of 99.9%. No buffer controls/adjusters are needed in the unit since independent read-out is shown for a given solution, test or buffer. In addition, incorporation of a temperature control has been tentatively avoided as the temperature coefficient with respect to any variation in temperature at ambient conditions is too small to appreciably affect the output. However, these controls are being adopted for another refined unit. The unit may be used in two modes: as a millivoltmeter with a range of 0 to 2000 mV, and as a pH meter with a range of 1 to 14 pH units. The calibration of the mV readings may be translated directly into pH values using solutions of known pH. Conventional glass and calomel electrodes can be used with the unit, irrespective of the make. Also, precise measurements of potential difference existing between carbon electrodes incorporating salt-bridging is also possible. A positive display stands for acidic medium (pH $<$ 7), while a negative one for basic medium (pH $>$ 7).

A zero mV display corresponds to pH 7. Since mV Vs. pH calibration is a function of specific electrodes used at a given solution temperature, no such interrelation is given here. Shielded wire cell connectors are recommended to take care of any capacitance fluctuations, the same being true about the cable connecting the cell terminals with the ICL circuitry. The shielded cable must be terminated as close as possible to the ICL. Since parts location is not critical, the printed circuits of the power supply and the mV unit may be housed comfortably in a wooden or plastic cabinet of any proper shape and size (Fig. 3). The cost of the finished product is about Rs. 550 or US $ 28. All the components are available from local electronic supply shops.

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