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Evaluation of the performance of a microprocessor-based colorimeter

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Colorimetric estimations have an important role in quantitative studies. An inexpensive and portable microprocessor-based colorimeter developed by the authors is described in this paper. The colorimeter uses a light emitting diode as the light source; a pin-photodiode as the detector and an 8085A microprocessor. Blood urea, glucose, total protein, albumin and bilirubin from patient blood samples were analysed with the instrument and results obtained were compared with assays of the same blood using a Spectronic 21. A good correlation was found between the results from the two instruments.

Introduction

Estimating the amounts of urea, glucose, protein and bilirubin in blood is important in the diagnosis of such disorders as diabetes, kidney disease and liver malfunction. Developments in diagnostic techniques and electronic equipment have made it easier to carry out various body function tests; this paper describes a system for the analysis of blood biochemical parameters.

Instrument

A block diagram of the instrument is shown in figure 1. Light emitting diodes (LEDs) are used as the light source because LEDs offer a fixed wavelength, narrow emission profile and low power requirements. Because the band width is narrow, filters are not required. LEDs with emission peaks at 560 nm, 580 nm and 630 nm were positioned on one side of a well containing the test solution in a cuvette; a photodetector was placed on the opposite side [1, 2]. The unit compares transmittance of sample with a reference. Transmittance signals are fed through the A/D converter to the microprocessor for further processing for absorbance, and, finally, the concentration of unknowns in the sample are displayed and printed out.

The system was designed to allow different modes of operation. The first operating mode checks the 'zero' position (calibration), and then autocalibrates to 100% transmission (T) with distilled water at a particular wave length. The next operating mode is to put the blank reagent, as well as standard known concentration solution, in the cuvette and store the absorbance value in the memory. The last operating mode is then used and the results are displayed. A flow chart of the operation of the system is given in figure 2.

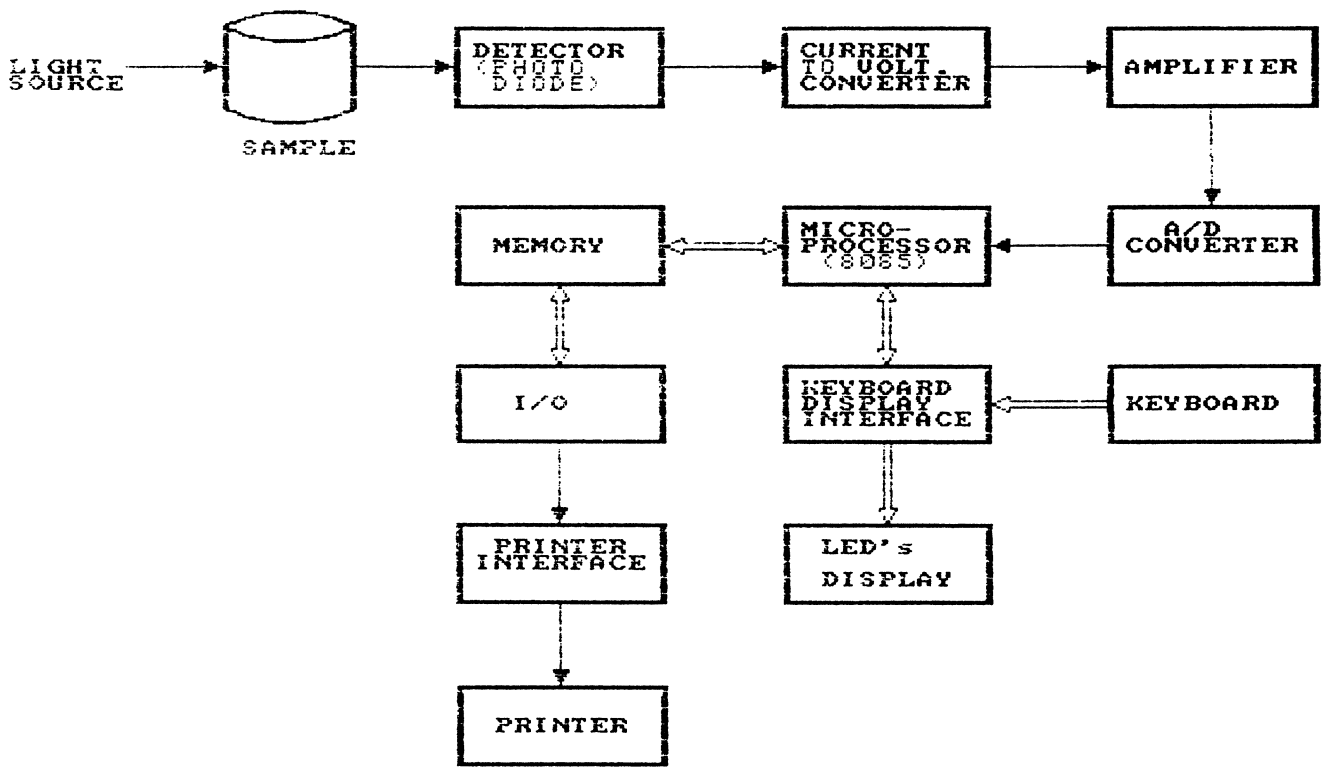

Figure 1. Block diagram of microprocessor based colorimeter.

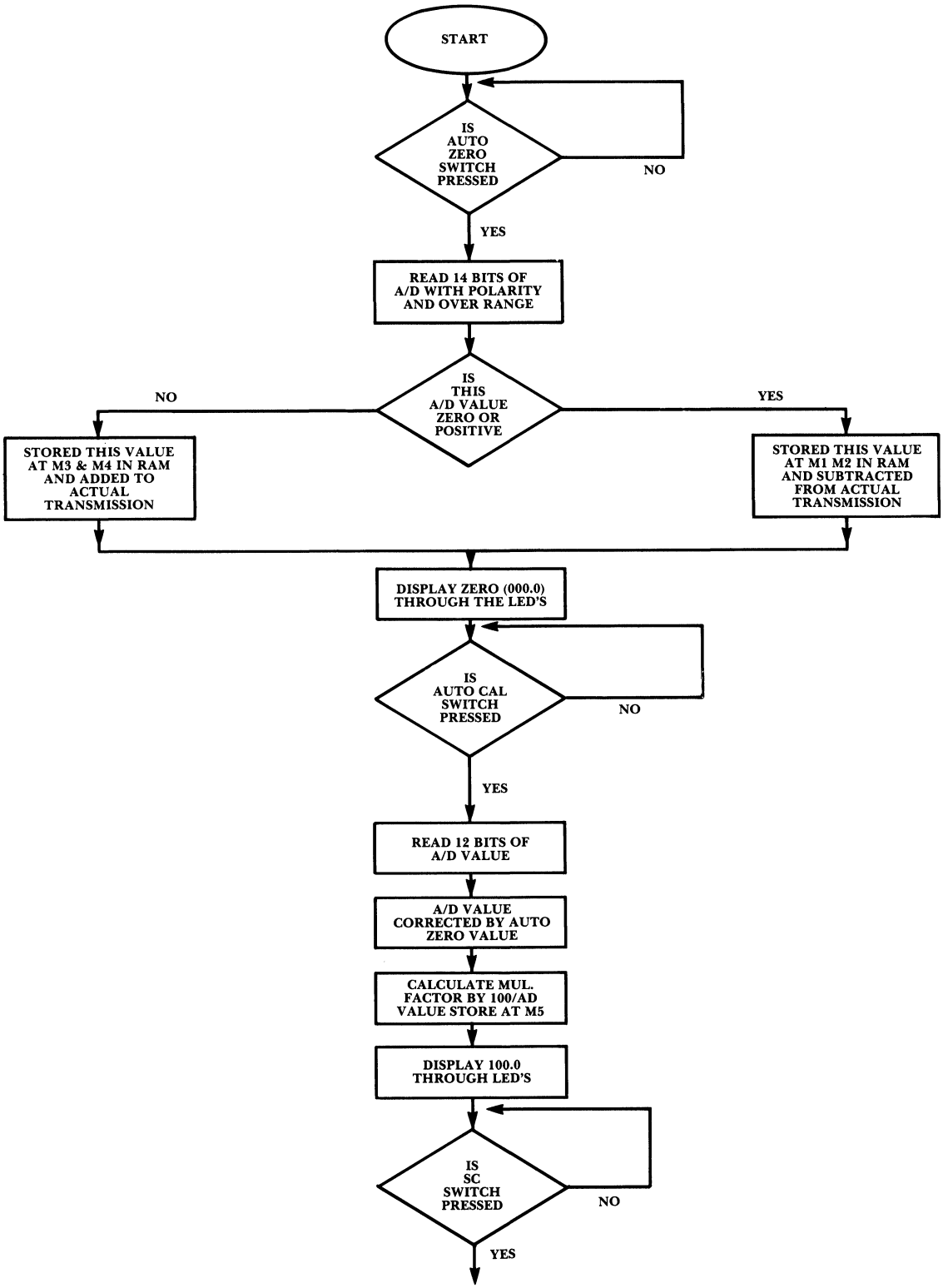

Figure 2. Flowchart of the operation sequence.

Results and discussion

Photometric stability of the instrument was studied over 30 min with distilled water at 100% transmission (T) – stability was achieved after 10 min. Concentration linearity was evaluated using a standard solution prepared for each parameter.

Blood samples were taken from patients. Blood urea, glucose, total protein, albumin and bilirubin were assayed using the Thiosemicarbazide, Nelsonsomogi, Biuret, Bromocresolgreen and Jenedrassik methods respectively. Blood urea, total protein, glucose were assayed at 560 nm, albumin was measured at 630 nm and bilirubin at 583 nm using different light emitting diodes.

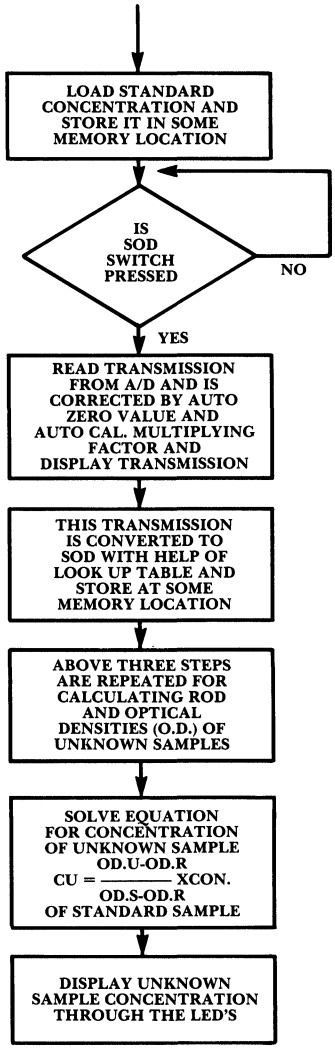

Figure 2 (continued).

Table 1 compares the results obtained with the authors instrument with those obtained with a Spectronic 21. Good correlation was found between the two sets of results. The following regression equations and coefficients of correlation were observed:

Urea	$R^2 = 0{\cdot}998$;	$y = 0{\cdot}994x + 0{\cdot}569$	(1).
Glucose	$R^2 = 0{\cdot}996$;	$y = 0{\cdot}956x + 5{\cdot}832$	(2).
Total protein	$R^2 = 0{\cdot}958$;	$y = 0{\cdot}953x + 0{\cdot}359$	(3).
Albumin	$R^2 = 0{\cdot}969$;	$y = 0{\cdot}971x + 0{\cdot}019$	(4).
Bilirubin	$R^2 = 0{\cdot}999$;	$y = 1{\cdot}016x + 0{\cdot}809$	(5).

Table 1. Regression analysis.

Parameters	No. of observations	Mean value CSIO Colorimeter	Mean value Spectronic 21	R^2	X Coefficient	Regression line
Urea	50	67·576	67·760	0·998	0·994	$y = 0{\cdot}994x + 0{\cdot}569$
Glucose	22	152·99	152·22	0·996	0·956	$y = 0{\cdot}953x + 5{\cdot}832$
Total protein	24	5·84	5·92	0·958	0·953	$y = 0{\cdot}953x + 0{\cdot}359$
Bilirubin	11	8·9	9·0	0·999	1·016	$y = 1{\cdot}016x + 0{\cdot}809$
Albumin	20	4·18	4·04	0·969	0·971	$y = 0{\cdot}971x + 0{\cdot}019$

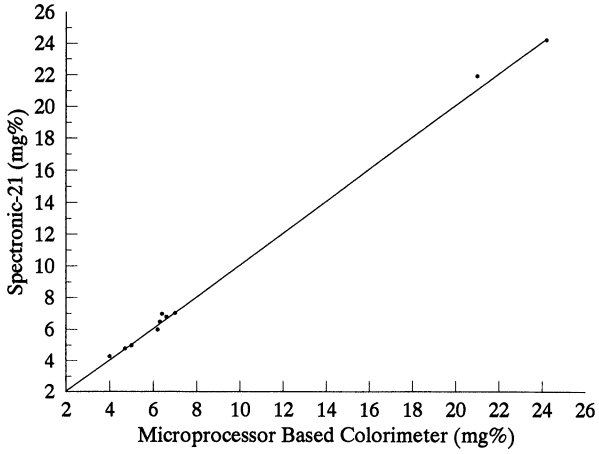

Figure 3. Comparison of results for bilirubin determined on the Spectronic-21 (y-axis) and the microprocessor-based colorimeter (x-axis).

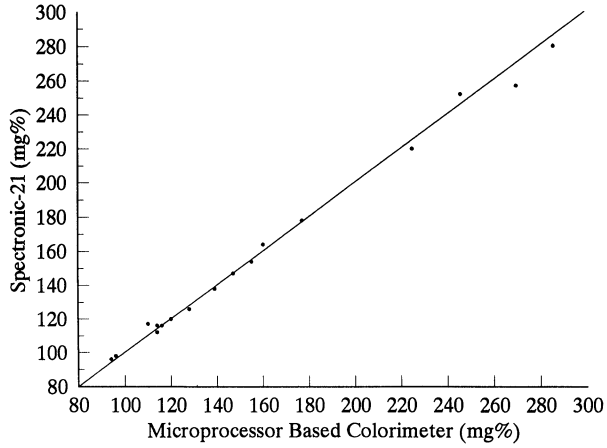

Figure 4. Comparison of results for glucose determined on the Spectronic-21 (y-axis) and the microprocessor-based colorimeter (x-axis).

The values of serum bilirubin and glucose assays obtained with microprocessor-based colorimeter were plotted against those obtained with the Spectronic and are shown in figures 3 and 4.

Conclusion

The results indicate that the instrument has a precision and reproducibility which is at least as good as a commercial instrument. In addition, the system has a number of attractive features of the system: for example no filter is used, concentrations are printed out, and there is no possibility of confusion over the sample number being tested.

References

1. Rose, A. W. and Steadman, J. W., *Clinical Chemistry*, **20** (1974), 613–614.
2. Jaffar, M. and Zahid, Q., *Journal of Chemical Education*, **85** (1988), 1099–1100.