ROHINI
COLLEGE OF ENGINEERING AND TECHNOLOGY
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DEPARTMENT OF BIOMEDICAL ENGINEERING

BM3491 Biomedical Instrumentation

UNIT- V BIOCHEMICAL MEASUREMENTS

5.4 Blood Gas Analyzers

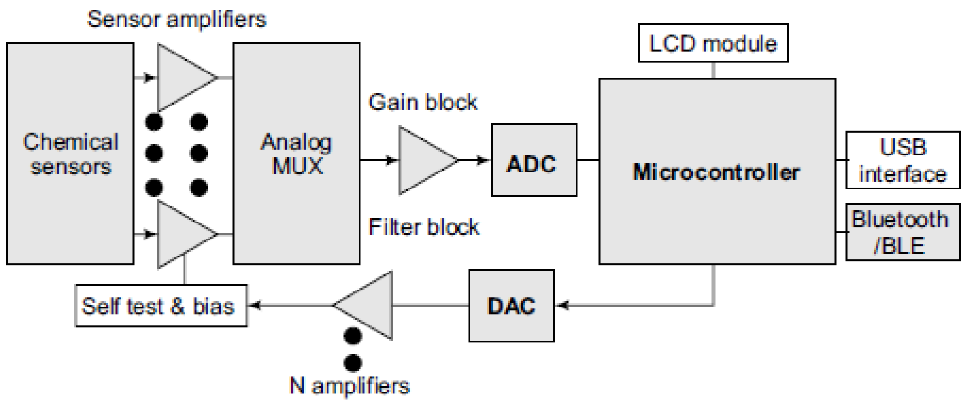
Blood gas analysers are designed to measure pH, pCO2 and pO2 from a single sample of whole blood. The size of the sample may vary from 25 µl to a few hundred microlitres. The estimations take about 1 minute. With built-in calculators, the instruments can also compute total CO2, HCO3 and Base Excess. A typical block diagram of a blood gas analyser machine is shown in Fig. 15.9

In this machine, separate sensors are used for pH, pCO2 and pO2. The outputs from multiple sensors and calculators are driven through a multiplexer to an analog-to-digital converter (ADC). The data is processed in the microcontroller, which is connected to a PC or other instruments through RS-232, USB, or Ethernet. A digital-to-analog converter (DAC) is often used to calibrate the sensor amplifiers to maximize the sensitivity of the electrodes.

Modern blood gas analysers increasingly employ a touch screen in combination with a graphical user interface (GUI) to make the programming process more intuitive. The instrument contains three separate high input impedance amplifiers designed to operate in the specific range of each measuring electrode. A separate module houses and thermostatically controls the three electrodes. It also provides thermostatic control for the humidification of the calibrating gases. A vacuum system provides aspiration and flushing service for all three electrodes. Calibrating gases are selected by a special push button control and passed through the sample chamber when required.

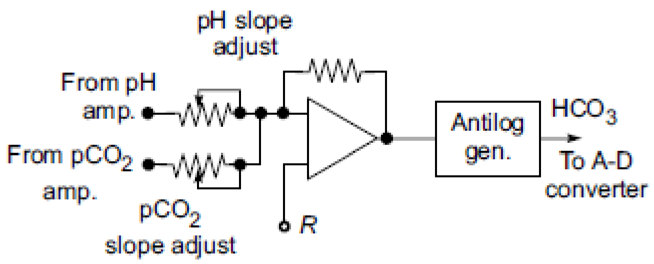
Two gases of accurately known O2 and CO2 percentages are required for calibrating the analyser in the pO2 and pCO2 modes.

The gases required are: O2 value of 12% Cal and 0% Slope and CO2 value of 5% Cal and 10% Slope. These gases are used with precision regulators for flow and pressure control. Two standard buffers of known pH are required for calibration of the analyser in the pH mode. The buffers that are used are 6.838 (Cal) and 7.382 (Slope). It is generally recommended that the sample chamber should control 7.382 buffer when in the standby mode. Microcontroller



➤ Fig. 15.9 *Block diagram of a complete blood gas analyser (Adapted from M/s Texas Instruments)*

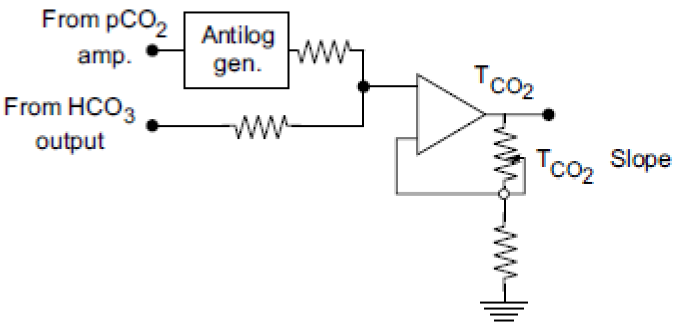
Input signal to the (HCO3) calculator (Fig. 15.10) comes from the outputs of the pH and pCO2 amplifiers. The outputs are suitably adjusted by multiplying each signal by a constant and are given to an adder. The next stage is an antilog-generator similar to the one used in a pCO2 amplifier. The output of this circuit goes to an A–D converter for display. Resistance R is used to adjust zero at the output.



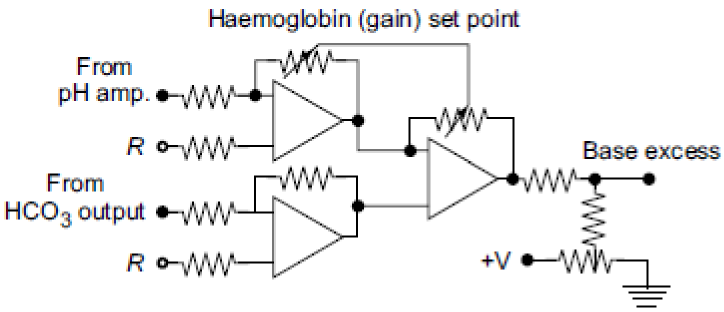
➤ Fig. 15.10 *Circuit diagram for computation of bicarbonate (HCO_3)*

Total CO2 is calculated (Fig. 15.11) by summing the output signals of the (HCO3) calculator and the output of the pCO2 amplifier. Facilities for adjusting the slope and zero at the output are available.

The base excess calculator (Fig. 15.12) consists of three stages. In the first stage, the output of the pH amplifier is inverted in an operational amplifier whose gain is controlled with a potentiometer (Haemoglobin value) placed on the front panel. The output of the HCO– 3 calculator is inverted in the second stage. The third stage is a summing amplifier A3 whose output is given to an A–D converter.



➤ Fig. 15.11 *Circuit diagram for computation of total CO_2*



➤ Fig. 15.12 *Circuit diagram for computation of base excess*

The three electrodes (pH, pO2 and pCO2) are housed in a thermostatically controlled chamber. It also provides thermostatic control for the humidification of the calibrating gases. The thermal block and the humidifier block heat control circuits are of the same type (Fig. 15.13).

The temperature is set with a potentiometer for exactly 37°C. The heater circuit is controlled by a thermistor in the block, which acts as a sensor. As the heat increases, the resistance of the thermistor decreases. At 37°C, the thermistor is calibrated to have a resistance of 25 K ohm. Supposing the temperature of the block decreases, the resistance of the thermistor will increase. The increase in resistance will cause the voltage at inverting input of op-amp to become more negative. This results in the output voltage becoming more positive, increasing the base current of transistors T1 and T2. The increase in base current increases the collector current, which goes directly to the heater resistor on the block. As the heater resistor heats up the block, the thermistor will decrease until it returns to 25 k ohm.

Many of the blood gas analysers have a provision for checking the membrane of pO2 and pCO2 electrodes. In the check position, a potential is applied across the membrane. Any leak in the membrane of sufficient magnitude will result in a considerable lowering of the resistance may be from 100 MW to 500 kW. The change in resistance can be used to have a change of potential to switch on a transistor, which would cause a lamp to light on the front panel of the instrument. This would indicate that a new membrane is needed.

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