ABSTRACT

General anaesthesia allows patients to undergo surgical procedures without the distress and pain they would otherwise experience. However, in about one in five hundred, the anaesthesia does not work, the patient feels the full pain but cannot communicate because of muscles being paralysed by drugs. Existing monitoring techniques depend on indirect measurements or qualitative observations and cannot give the right information in such cases. Heart rate variability and Bispectral Index (the latter based on brain signals, EEG) are recent monitoring techniques, but they too are not also foolproof. When a patient is anaesthetized, the hearing ability is the last sense to disappear, and measuring this ability could give a very good indication of the state of anaesthesia. To assess the hearing ability objectively an evoked brain potential known as Audio Evoked Response (AER) is very effective. As the patient is anaesthetized the AER fades out gradually till it vanishes on full anaesthesia. However this test takes a few minutes, and so is not suitable for instantaneous feedback necessary for drug administration. We feel AER could be useful at least in the beginning, before the actual surgery is started, to ensure that the patient has really been anaesthetized. This could also be repeated at certain intervals during surgery.

The present work is part of an on-going project by the University of Dhaka in developing a practical and effective anaesthesia monitoring system. Previously, aspects of anaesthesia had been studied by another group of BRAC University students and an attempt was made to understand the differences in EEG signals that may be brought about by anaesthesia. In this project we will be examining and developing a PC based AER system.

AER involves producing a series of click stimulii at the patient's ear via a headphone or a loudspeaker and picking up the evoked voltage signals from the brain using electrodes fixed at suitable locations on the patient's head. The AER signals, which are of the order of 10µV, are usually associated with thousands of time larger mains borne 50Hz noise. This noise will need minimization using a front end instrumentation amplifier with a very large CMRR. This will then need to be filtered, further amplified, electrically isolated and received by the computer via an analog interface, which has to have an A/D converter. The click generator will also need to send a trigger pulse to the computer in order to initiate the process of data acquisition for about 500ms each time (considered as one sweep of data) under software control. So development of appropriate software is also an essential part of this project. The reduction of the 50Hz noise using hardware as mentioned above is not adequate for this application. Besides, spontaneous EEG from brain also clutters the signal and appears as noise. Since these noise potentials do not have any phase relationship with the trigger of the evoked response, these can be eliminated using a signal averaging technique, employed through software. About 50 to 100 sweeps of data will be collected and averaged for this purpose.

In the last semester, we gathered relevant information for this project, made the initial overall design, and developed a pulse generator to give a click sound output using a headphone. Narrow electrical pulses (~1 ms width) produced by the click generator could provide the necessary sound stimulus (approximately 60 to 80 db) to the ear via the headphones.

This semester, we first worked on the Front-end amplifier circuit using IC's available in the laboratory. We used an instrumentation amplifier IC - AD521, and made up instrumentation amplifiers using op-amps available in two quad op-amp IC packages - TLO74 and LM324. TL074 has an FET input while LM324 uses bipolar transistors. CMRR values of approximately 104dB, 96dB and 86dB were obtained using AD521, LM324, and TL074 respectively. Obviously the decision went in favour of using the IC AD521 which requires a few external components to make a complete instrumentation amplifier.

Since this equipment is supposed to be used in a hospital, special electrical isolation circuitry needs to be incorporated to save a patient from ‘microshock’ hazards that can result from the use of ordinary power transformers, or in case there is an accidental connection of the equipment to the mains live wires. The optical isolation will be performed using an opto-coupler IC 4N35, and an analogue isolation technique, developed at Dhaka University, will be used. Finally the output will be converted to digital values using an 8 bit A/D converter, ADC0820 for acquisition in a PC through its printer port (LPT1).

Software will be developed under MSDOS using either QBASIC or C language. The software will first acquire the trigger signal from the click stimulator. On receiving a trigger it will acquire AER data for about 500ms in one sweep, at a sampling frequency of about 1kHz. It will also perform the task of signal averaging by acquiring the required number of sweeps in succession. The averaged data will be displayed graphically on a video monitor as a function of time. Absence of AER will confirm the success of anaesthesia.