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Design of Microcontroller Based Cost Effective Portable Detection Circuit for Pesticide Recognition

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Abstract: ***Excessive use of pesticides for better agricultural productivity poses serious threats to human health. Depending upon the duration and dose of exposure, deleterious effects may be intense or moderate, which may be one of the root causes of several diseases such as diabetes, asthma, cancer, cardiac attack, fertility defects etc. Inhibition of an acetylcholinesterase enzyme activity is commonly associated with pesticide exposure and as a result acetylcholine levels are elevated in blood of an exposed person. Common tools for detection of pesticide exposure measure an enzyme activity for acetylcholinesterase (ACHE), an important enzyme that regulates the neuro transmission functions in the human body. Proposed work includes an electronic design and simulation of microcontroller based portable detection circuit using electrochemical amperometric instrumentation for measurement of an acetylcholinesterase concentration in human blood. Handheld detection circuit consists of AT89C51 microcontroller, Analog to digital converter ADC0804 and Liquid Crystal Display Module LM016L.To program the microcontroller, Embedded C is used, due to their inherent characteristics of adaptability and portability across a wide assortment of hardware platforms. The developed detection circuit for biomonitoring of pesticides is cheap, flexible and covers wide range as compared to commercially available ones.***

Keywords- Amperometric, Analog to digital converter, Biosensor, Liquid Crystal Display, Pesticides.

I. INTRODUCTION

Pesticides are abusively used to meet the developing productivity needs and resistance against pest attack, severely influencing the biotic and abiotic species living in an environment [1], [2].Their continual deposition in the environment even at lower concentrations can cause ill health effects in target as well as non target organisms [3] due to their exceptionally deadly nature, persistent ability even after enduring exposures, greater stability and bioaccumulation capacity in the food chain. Thus, continuous toxicity biomonitoring of these perilous substances in the body fluids by more sophisticated means involves significant concern. Intemperate use of pesticides specifically organophosphates and carbamates are mostly affecting the farmer community since majority of the cultivating in India especially in Punjab are small homestead lands [4].

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People are not enough rich and educated to understand the issues related with inordinate use and their poisonous impacts on the human health. To meet their basic necessities with the available resources is extremely a major issue for these people.

Chromatographic techniques available for pesticide acknowledgement are expensive with lower shelf life, longer response time; require well educated personnel to operate and non availability of field detection [5].

With the impediments in the existing methods, an endeavor is made to design and simulate a compact electronic detection unit for qualitative and quantitative recognition of toxic chemicals in human blood. The above target can be accomplished by proper selection of bioreceptors, modified electrode surfaces and design of highly specific detection circuits [6].

II. RECOGNITION CIRCUIT DESIGN

Electrochemical biosensor is the most broadly recognized biosensor for detection of lethal chemicals because of simple instrumentation, cheap availability, wide linear range, lower detection limits and movable detection unit [7]-[9]. Block diagram and schematic design for pesticide detection in human blood is shown in Fig. 1 and 2.

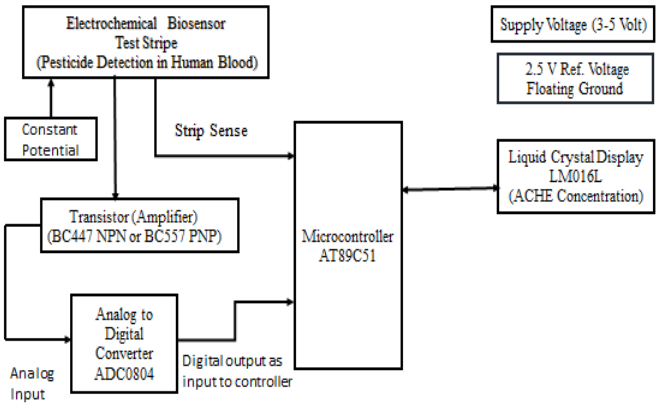

Fig. 1. Block diagram of portable recognition circuit for ACHE concentration measurement.

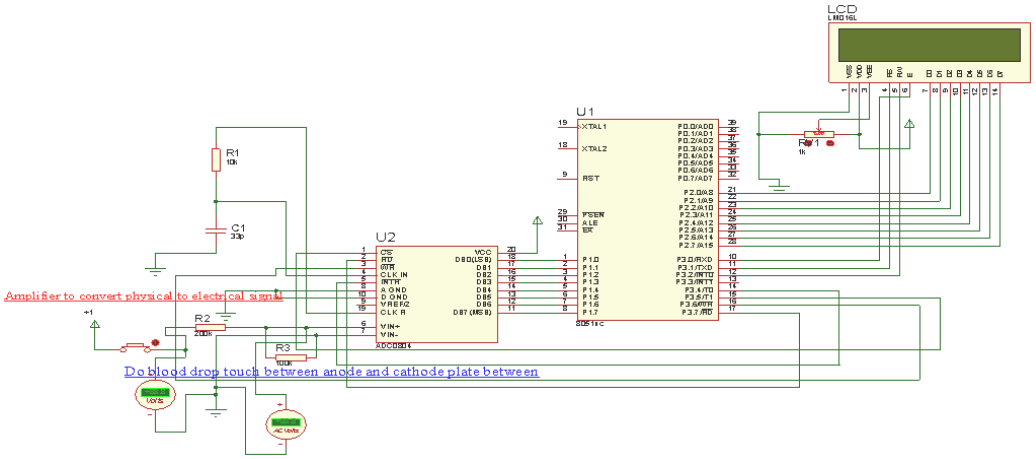

Fig. 2. Schematic design of portable recognition circuit

A. Working principle

Cholinesterase's are the family of enzymes that are inhibited by harmful chemicals for example pesticides and nerve agents. Acetylcholinesterase is the special enzyme belonging to cholinesterase family present in human blood in immense amounts that perform the hydrolysis of different neurotransmitters [10]. Since organophosphates and carbamates are ChE inhibitors, thus cholinesterase (ACHE) activity estimation is an astounding biomarker for pesticide exposure [11] and human medical problems. The present paper detection principle was the enzymatic activity (ACHE) measurement, before and after exposure to pesticides by measuring the current generated by oxidation or reduction of an electroactive compound, produced by enzymatically hydrolysis of substrate when a suitable potential is applied between the electrodes of an electrochemical cell [12]. Hydrolysis of substrate acetylthiocholine in presence of ACHE is shown in the equation below.

$$ATCh + H_2O \xrightarrow{ACHE} TCh + CH_3COOH \quad (1)$$

The general systems used for analyzing electrochemical behavior of bioreceptors immobilized on the transducer surfaces incorporates cyclic voltammetry [13], polarography, impedance spectroscopy [14] and chronoamperometry.

B. Different approaches used for biomonitoring pesticide poisoning in human blood

Conventional Ellman assays utilized for lethal chemical recognition in body fluids are invasive, tedious and non-specific i.e. accurate information regarding sort of pesticide causing neurotoxic impacts cannot be unequivocally shown. Novel approach for evaluating pesticide toxicity involves the utilization of an Anti-ACHE antibody to capture ACHE pursued by its electrochemical detection [15]. Another similar approach incorporates the estimation of elevatedacetylcholine levels as a biomarker for pesticide exposure.

III. BIOSENSOR

Biosensor is a mixture of bioreceptor, transducer and signal conditioning unit that performs the multiple functions such as target analyte recognition, transformation of physicochemical changes into quantifiable electronic signals and processing of electronic signals for manipulating the data into human readable form [16], [17] as illustrated in Fig. 3.

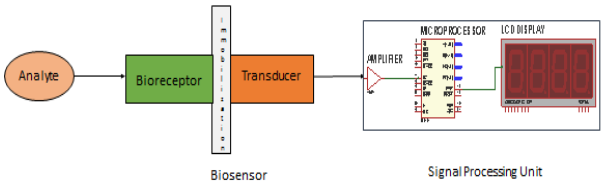

Fig. 3. Components of Biosensor

A. Data Acquisition Unit

When blood is dropped on the test stripe, it reacts with the enzyme ACHE on the surface in presence of substrate to produce acetylthiocholine, whose oxidation generates the flow of current. This current in micro ampere range is converted into equivalent analog voltage through current to voltage converter. Analog voltage so obtained is then amplified and provided to microcontroller for further action. On the other hand, when an electrochemical stripe is inserted in the detection circuit, microcontroller senses the presence of chip, performs analog to digital conversation and drives the LCD display to compute target analyte (ACHE) concentration. Flow chart shown in Fig. 4 represents the steps for generating electric current signal to obtain target analyte concentration. KEIL µVision IDE software is used for generating hex files as output files by composing the codes in EMBEDDED C as inputs to software for essential conversion and measurement.

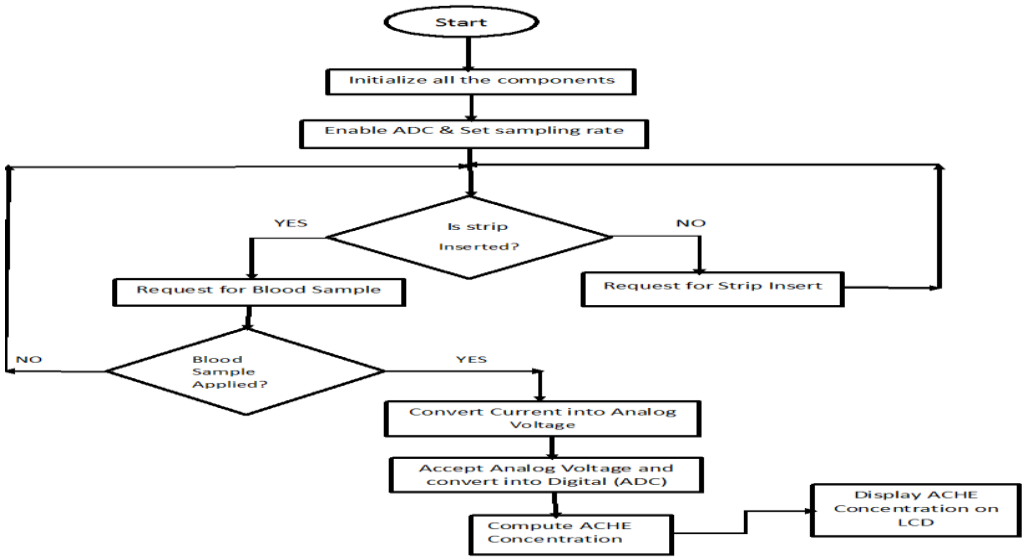

Fig. 4. Basic flow chart to measure acetylcholinesterase concentration in human blood

B. Microcontroller

Present design includes an Atmel AT89C51 µc, 40 pin integrated circuit having 4kB on chip programmable memory, 128 bytes RAM, 16-bit address bus, 4 input/output ports, 2 External interrupts and Universal asynchronous transmitter/receiver (UART) acting as an intermediate between serial and parallel interface. The utilized microprocessor incorporates all the essential functions required to meet the proposed design specifications [18], [19].

C. Analog to Digital Converter

In the present study 8-bit ADC (0804), a 20 pin IC is utilized that accepts the analog voltage as input and convert it into digital equivalent values varies from (0 to 255). (DB1-DB7) are data pins that are interfaced with µC 8051 Port 1 pins (P1.0- P1.7). Time taken by ADC to convert analog into digital value is decided by clocking signals applied at CLKIN and CLKR pins through different resistor and capacitor combinations. Read (pin 2) and write (pin 3) of ADC are connected to read (p3.7) pin 17 and write (p3.6) pin 16 of µC 8051. To terminate the conversion process from analog to digital, interrupt pin (pin 5) of ADC goes low and by making CS=0 and high to low pulse at RD pin, data can be out from ADC chip [20].

D. Liquid Crystal Display

LM016L LCD (16*2) display is most commonly used display with inbuilt microcontroller. Each character can be displayed in 5* 7 matrix. Port 2 pins (P2.0- P2.7) of µC are connected to 8 data pins of LCD 7-14 (D0-D7) for sending data and commands. Register select (command/data), read/write and enable pins are control pins to perform read and write operation.

E. Embedded C

Keil, an incredible software that provides source code editing, debugging, compilation and simulation in single powerful environment for effective computation of complex problems. This software generates hex files as outputs by writing source codes in Embedded C with inbuilt data types, operators and function rich library to program microcontroller [21]. The cost associated with portable detection circuit is depicted in Table I.

Table I: Cost of Portable Detection Circuit

Component Name	Specifications	Quantity	Price ($)
Microcontroller (AT89C51)	8 bit, 4kB code, 12 MHz Clock frequency, 2*16 bit timers and UART	1	1.1
Aanlog to Digital Converter (ADC0804)	8 bit µprocessor with 8 channel multiplexer , step size 19.53 mV	1	1.8
LCD Display (LM016L)	16*2 display, 250kHz clock frequency	1	1.91
Resistors (R1, R2, R3)	10kΩ, 100kΩ, 200kΩ	3	0.03
Capacitor(C1) AVX0402NPO33P	33pF , 50V nickel barrier SMT ceramic chip	1	0.05
Potentiometer (RV1)	1kΩ	1	0.06
Switch	SPST push button	1	0.05
Total			Cost
5 $			

IV. RESULTS

The performance of the system for pesticide recognition in human blood is effectively computed based on ACHE enzyme inhibition as shown in Table II. When the test stripe has been inserted in detection circuit, microcontroller senses the presence, and when the blood sample is dropped, based on its variations in the thickness or concentration, the ACHE value is displayed on LCD screen. Connect an active potentiometer (0-10kΩ), with positive end connected to voltage source of 5 V and negative end attached to ground and variable lead connected to analog input end and checks the variations as different ACHE concentration values as shown in Fig. 5.

Table -II: Computation of Acetylcholinesterase values with change in resistance and supply

Variations on Potentiometer	Variable Resistance (0-10 kΩ)	DC Supply (0-5V)	ACHE Value
10%	1	0.5	0.470
20%	2	1	01.00
30%	3	1.5	01.470
40%	4	2	02.00
50%	5	2.5	02.470
60%	6	3	03.00
70%	7	3.5	03.480
80%	8	4	04.010
90%	9	4.5	04.480
100%	10	5	05.010

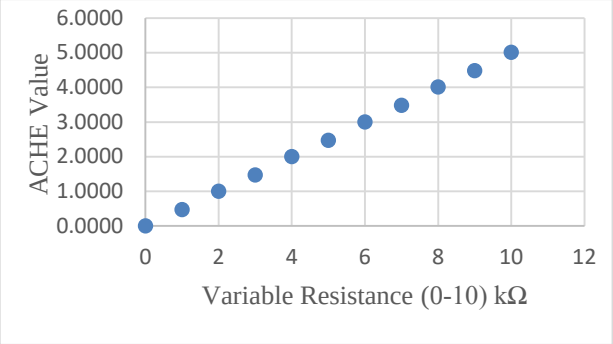

Fig. 5. Variation of ACHE value with resistance change

V. CONCLUSION

Recognition of pesticides in body fluids through smart and portable instrumentation is the main thrust of today's scenario due to their deleterious impacts on health of human well beings. Design of pesticide recognition circuit, depending on thickness of blood presented in the paper, describes the resistance variations to measure various ACHE concentrations. Proposed methodology based on ACHE enzyme inhibition is cost effective, portable and enable the common man for their biosample tested without requirement of heavy instrumentation. In the future, research should be focused on the commercial availability of these electrochemical devices so that developing and underdeveloped countries can take the advantage.

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