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Microconverter AduC 842 and LabVIEW bench – a best suitable approach for real time plotting of Pressure Area Isotherm of monolayer

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Abstract:

A real time system has been developed for measuring and plotting of surface pressure area isotherm of Langmuir films for studying phase transitions of the monolayer at National Chemical Laboratory, Pune, India. Microcontroller and LabVIEW platform is best suitable combination for gearing up any scientific application for measurement, data acquisition and control. With the technology advent in microcontrollers, a new era in the form of Microconverter is available at user's door step. The attempt has been made to develop stand alone real time system using base intelligence of Microconverter ADuC 842 for measuring surface tension exerted by Langmuir films. The films formed on the surface of the water, are compressed by smooth and precision barrier mechanism. A DC motor is used to control the speed and direction of the barriers. I^2C compatible EEPROM is provided on – board for data storage and it can be communicated to PC through LabVIEW VISA for further analysis. LabVIEW is intuitive graphical programming language designed for engineers and scientists. The other features provided are, In-circuit Programming for firmware updating, keyboard functioning for special routine executions, I^2C compatible RTC and battery backup. The software has been completely developed using assembly language programming for Microconverter module. Front end development has been carried out using LabVIEW software for data acquisition and real time plotting of Pressure Area Isotherm.

Keywords:
Microconverter, Langmuir films, Surface tension, Barrier movement, LB Trough, LabVIEW, Virtual Instrumentation

Introduction:

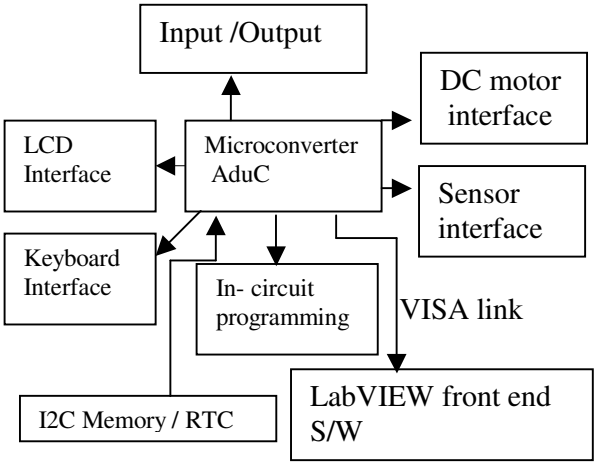
Langmuir film consists of surface active material trapped at air – water interface and formed on the water surface. Sweeping a barrier over the water surface causes the molecules to come closer together and eventually to form a compressed ordered monolayer. The surface tension exerted

during the compression is very much useful to understand the phase behavior of the spread monolayer. The developed system is used to determine the surface pressure of the Langmuir films and thus plotting real time surface pressure area isotherm to study phase transitions.

Instrumentation Concept:

The stand alone Microconverter module has been developed using Microconveter ADuC 842 for real time acquisition of surface pressure values. In addition to the normal features of 8051 some of the best and useful features of ADuC are 640 bytes Flash/EE data memory, high performance self calibrating 8 channel ADC with 12 bit resolution with temperature sensor, on chip RTC -can be used for interrupt driven, dual DAC with 12 bit resolution, ADC DMA function. With ADuC, faster speed is achieved due to 50 nanosecond machine cycle. With this operating speed, on-chip ADC conversion is possible in 2.5 microseconds i.e. in 50 machine cycles. The pressure sensor used is model PS4 from NIMA Technology, England to measure the surface tension of the pure water and that with the monolayer. A 12- bit ADC is used to sample the voltage generated by pressure sensor. The pressure sensor is calibrated for pure surface tension of the Millipore water, which is 72.8 mN/m. The indigenous development of Langmuir trough with barrier mechanism has been carried out at National Chemical Laboratory, Pune. (Please refer to Figure 2). The films are compressed and decompressed using Teflon barrier. The precise horizontal movement of the barrier is controlled using DC motor. The rate of compression and decompression is controlled using on chip 12 bit DAC. A control circuitry using L298 is developed for dual direction control of DC motor. The graphic LCD is employed for real time plotting of surface pressure area isotherm and for displaying real time values of surface pressure and area per molecule. With the facility of graphical LCD the module can be used as standalone module in case of PC failure. ADuC842 has on chip I2C hardware interface. With this facility, external I^2C compatible EEPROMs (two no.) are used to store data on board. The stored data can be uploaded through serial port to PC as and when required with key stroke. The developed microcontroller PCB also contains the facility of in-circuit programming for ADuC842 chip. A keyboard facility is provided for user to input the required parameters such concentration of the monolayer, molecular weight volume inserted on water surface. Complete software development of microconverter module has been done using assembly language programming. Stored data can be upload to PC using LabVIEW VISA feature.

Virtual Instrument Software Architecture (VISA) can control GPIB, Serial or computer based instruments. Front end software development for real time plotting of Surface Pressure Area has been carried out using LabVIEW software.



SYSTEM BLOCK DIAGRAM

A facility of writing data in to a excel / text file format is provided on PC. The Microconverter module consists of AT24C64 for I^2C memory, DS1307 for I^2C RTC, MAX813 for power supervisory circuit, MAX 232 as UART port driver and interface for graphic LCD. (Please refer to Fig. 1). Xaimen GDM12864A graphic LCD is used which is 128 X 64 pixel and having 0.48 x 0.48mm pixel size with backlight facility. System is secured and protected through password.

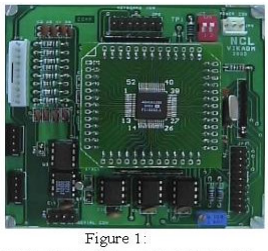


Figure 1:
Lilliputian Platform with ADuC 842

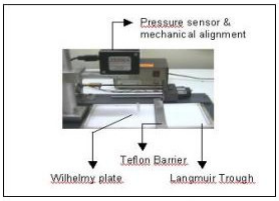


Figure 2:
Langmuir Trough setup

The software development has been carried out on two extreme fronts. For ADuC842, it is totally assembly language programming and front end software for communication with ADuC842 through RS232 & real time plotting using

LabVIEW, which is "G" language programming. For assembly programming development, no cross C compiler or any allied tools are used. This helped to even debug the real time bugs in LabVIEW programming.

Experimental details:

The monolayer is formed on a liquid sub phase which is usually high purity water contained in Teflon trough. The monolayer is compressed using a Teflon barrier to vary the surface molecular density or surface pressure. The surface pressure Π is defined as

$$\Pi = P_1 - P$$

where, P_1 is the surface tension of pure water, and P that of water with the monolayer.

Surface is measured by determining the force acting on the plate which is in contact with the sub phase. The plate is usually a chromatography paper which is suspended from pressure sensor (model PS4) which measures the force acting on it. The measurement of Π as function of area per molecule is plotted in real time on graphical LCD display and also on the PC monitor.

Testing:

A standard monolayer of stearic acid is used for testing purpose. An amount of 250 microliter of concentration 1mg/ml stearic acid has been spread on the subphase. Sub phase is usually high purity water (Millipore Milli-Q) contained in Teflon trough (20cmx10cm). Surface tension of the water (72.8 mn/m) has been measured first to standardize the process. The monolayer is compressed using a Teflon barrier to vary the surface pressure and in turn area/molecule gets calculated. The typical phase sequence seen on increasing the surface pressure is Gas (G), Liquid expanded (LE), Liquid condensed (LC), Solid and Collapsed state.

Conclusion :

Intelligent, compact hardware platform for ADuC 842 microconverter for real time plotting of surface pressure area isotherm of Langmuir films has been designed & developed and tested successfully at National Chemical Laboratory, Pune. The development is compact, handheld and cost effective with high precision measurement. The Lilliputian platform (size 8.7 x 9.0 cm) developed is first proto board with ADuC chip mounted on the piggy bag board, which can be minimized using SMD components, a real embedded system. This microcontroller module talks to PC through RS232 protocols. LabVIEW based software on PC takes care of data recording and real time plotting of Pressure Area Isotherm of Langmuir films. Battery backup provided for ADuC 842 micro module keeps the operation really in a real time in case of power failure. This engineering based development has become really useful for scientists to carry out interdisciplinary work.

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