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Microcontroller based Iontophoresis Power Supply with Data Acquisition System

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A B S T R A C T

Low cost, flexible low cost Iontophoresis power supply with data acquisition system based on 8051 family microcontroller (89S51/52) is presented. General purpose 8 bit ADC 0809 is used and thus the resolution is 1 part in 256 which suits most of the experiments, the clock is derived from a simple NE555 circuit. With suitable modifications, more than one channel from the ADC can be used. The Iontophoresis power supply provides selectable ON and OFF time duration with two thumbwheel switches. The output of the power supply is provided with a potentiometer to adjust the output current to the desired levels. Researchers in trans-dermal drug administration and Iontophoresis need such a flexible pulse power supply for optimization and characterization studies.

The data acquisition system works under program control and keeps on monitoring the signal at the analogue inputs and makes the digital equivalent available on the selected ports of microcontroller. The controlling program on a PC read this input at pre-decided time intervals and process accordingly. The data read can be saved in computer files for further processing.

Keywords : *Iontophoresis, Data Acquisition system, ADC, Trans-dermal drug delivery, Microcontroller.*

1. Introduction:

Search of new roots and techniques of drug administration gave rise to brisk activity in the area of drug delivery through skin and Iontophoresis is found to be a promising tool to this effect. The researchers working in this area need advanced electronics devices to suit their requirements of experimentation. In Iontophoresis there is a need of pulsating power supply whose characteristics can be controlled and modified as per need to optimize the design of Iontophoresis based drug delivery system. The research in the field of Microsystems is progressively directed towards smart electronic interfacing [1-3] which provides the ability of performing complex operations. Specially designed interfacing electronics for specific applications improve the performances and provide a user-friendly environment. Data acquisition system [4-7] is extensively employed in a number of automatic test and measuring equipments. They are used to collect the required data from any peripheral input devices, such as meters, sensors and etc. via controlling Program [8]. The measured data could be stored in the

PC in a file for further processing and the data can be displayed numerically or graphically as a curve on the screen [9].

A microcontroller (89S51/52)-based Iontophoresis power supply with data acquisition and control system [10-12] designed, constructed and tested is presented. The system makes use of printer port in SPP mode for input and output of digital data. The data transfer to the controlling computer was in nibble mode and for 8 bits of data two nibbles are used. The two nibbles of 8 bit data are read one by one by the computer side controlling program and combined to form the value read.

For generating pulsating voltage at a desired rate, port pin P0.0 is used which in turn is connected to a Darlington pair of IC ULN2803 to drive a 12 V relay with one changeover contact. The ON time and OFF time can be set with the help of two thumbwheel switches connected to port P1. The microcontroller firmware monitors these switches and provides necessary timing for switching the power supply. To display the selected options a LCD display is provided that displays the ON time and the OFF time selected.

As the experiment proceeds the transport across the membrane takes place and the concentration on the other side is of interest, thus to monitor the same one channel of ADC is made available to read in data from attached instrument. The ADC used (ADC 0809) has 8 analogue channels and thus the number of channels can be increased if needed.

2. Features of 89S51/52

The AT89S51 is a low-power, high-performance CMOS 8-bit microcontroller with 4K bytes of In-System Programmable Flash memory which is more than sufficient for small applications like the present system. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry standard 80C51 instruction set and pin-out. The on-chip Flash allows the program memory to be reprogrammed in-system using suitable programmer. By combining a versatile 8-bit CPU with In-System Programmable Flash on a monolithic chip, the Atmel AT89S51 is a powerful microcontroller which provides a highly flexible and cost effective solution to many embedded control applications. The AT89S51 provides the following standard features: 4K bytes of Flash, 128 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, two 16-bit timer/counters, a five-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. All the 32 I/O lines can individually be configured as input or output by writing a '0' or '1' to the corresponding line. In addition, the AT89S51 is designed with static logic for operation down to zero frequency allowing a flexible design. It supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. 89S52 has very much similar features and the programmable flash memory is 8K and RAM is 256 bytes (against 4K and 128 for 89S51).

3. Design Considerations:

The Iontophoresis power supply and data acquisition system was designed basically to provide pulsating power supply with desired specifications and monitor one analogue input. The ON and OFF time of the power supply can dynamically be set using two thumbwheel switches connected to port P1 of the microcontroller. The switching of power supply is accomplished using an electromagnetic relay driven by a Darlington pair from ULN2803. For simplicity the printer port was used in SPP mode and the data acquisition was implemented in nibble mode. A 16 character 2 line LCD display is connected to ports P0 and P2 to display the ON time and OFF time as selected by the settings of the thumbwheel switches.

For reading in the data by computer, additional circuitry is needed on the data acquisition system for multiplexing. For this purpose we used 74LS257 multiplexer that has tristated outputs. As two nibbles of the 8 bit ADC data are to be read, we used on data pin (D0, Pin No 2) from printer port to decide which nibble to read. Circuit diagram of the data acquisition system with multiplexing part is shown in Fig. 1 below.

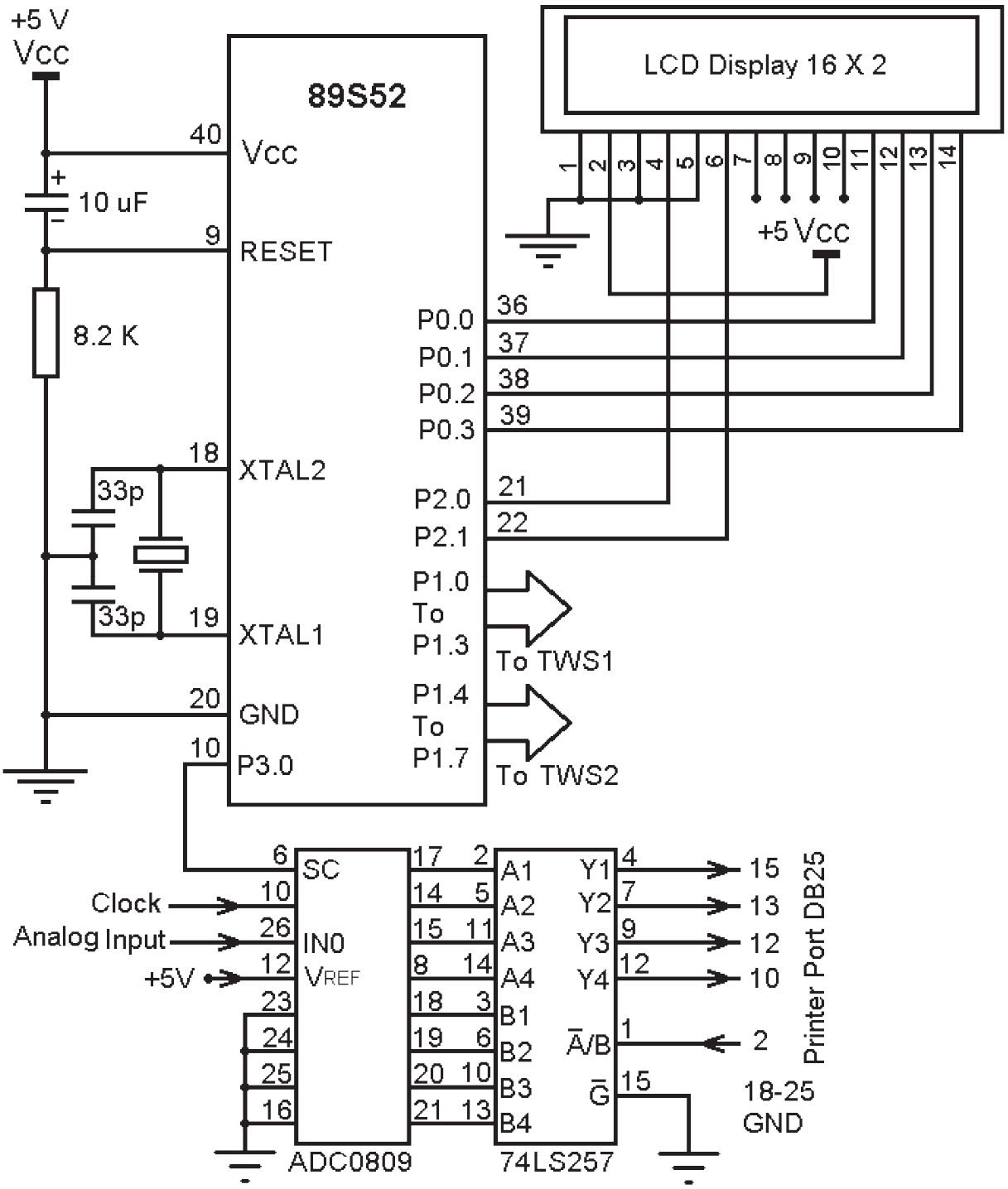

Fig. 1 Circuit diagram of the Iontophoresis power supply and data acquisition system.

The 4 bit bus from the 74LS257, the control signal coming from printer port of controlling computer and its ground connection i.e. 6 pins are brought on a single 8 pin header and a cable was constructed to connect to the 25 pin D type printer port connector on one side and 8 pin header on the other side. The entire system was constructed on a general purpose board fitted with minimum required system, IC's, crystal etc and ISP port for in system programming. The circuit was carefully constructed using necessary decoupling and taking care of stray pickups, the circuit diagram is shown in Fig. 1 and the actual assembly is shown in Fig. 2.

Fig.2 Iontophoresis Power supply and Data Acquisition System.

A program was developed to implement the controls discussed above in assembly language and it was debugged and assembled to generate.HEX file to be downloaded into the microcontroller. This code (Firmware) is then downloaded in to the microcontroller using a programmer, one can use a USB based ISP programmer. The program firmware can be modified easily to incorporate new modifications if needed.

After downloading the program into the microcontroller, it starts running independently and when connected to the computer, allows for the data transfer via printer port using appropriate controlling program using visual basic.

A user friendly program was written and tested in visual basic to monitor the input from the microcontroller board. Visual Basic does not have instructions to directly access the ports on the computer; to this effect an additional file input32.dll is needed that provides with the instructions for accessing the ports using Visual Basic. The program was successfully tested and the results obtained were found to be in agreement with what is expected. A screenshot of PC side controlling software is shown in Fig. 3, The analogue input was varied using a potentiometer to see the real time data acquisition and is displayed in graphical form.

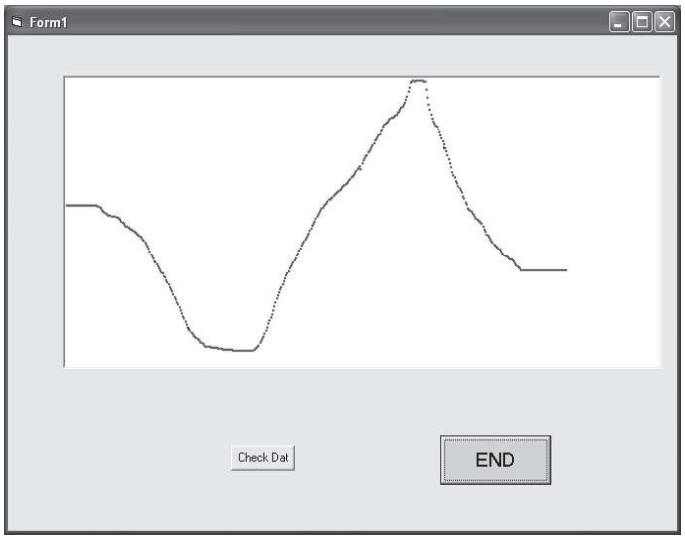

Fig.3. The input variation of the data acquisition system.

The data acquisition system was tested several times using standard input voltages to confirm the accuracy of measurement, it was found to be in good experiment with the expected value with an error of ± 1 bit as imposed by the ADC.

4. Conclusion:

The Iontophoresis power supply and data acquisition system based on 8051 family microcontroller (89S51/52) from Atmel Corporation is designed, developed and tested. The advantage of using a microcontroller based pulsating power supply is that the Iontophoresis study needs voltage pulses of desired duration over a long period of time and the duration and delay between two consequent pulses should be variable. This allows for a quantitative measurement of drug transport across membrane and thus finding out optimal characteristics of the applied pulses. The design is kept flexible so that more than one analogue channels of the ADC can easily be implemented with minor modification in hardware, firmware and controlling program.

5. Future Scope:

In view of the present needs and availability of microcontrollers with additional features, we plan to revise the whole system and design the same using AVR family microcontrollers having built in ADC with 10 bit resolution (1 part in 1024). Also latest desktop computers and laptops don't have parallel port, to keep the system versetile the data transmission will be implemented using serial communication with RS232 protocol.

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