

A Chest Compression System for Cardiopulmonary Resuscitation

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Abstract

A chest compression system for Cardiopulmonary Resuscitation (CPR) has been developed in house successfully. An electronic control unit has been developed and the details of construction and working principles are presented. Ambu manikin and the details of CPR software to analyze the data are explained. It is shown that with this indigenously developed chest compression mechatronics system it is possible to perform CPR satisfying AHA (American Heart Association) guidelines: 100 compressions per minute with a uniform compression depth of 50 mm.

Keywords: Micro controller, CPR, Parallel Manipulator, AHA guidelines.

1. Introduction

A recent U.S. National Academy of Engineering and Institute of Medicine study advocated the applications of engineering tools and information/communication technologies to improve the quality and productivity of the healthcare system [4]. Competing in a globalized market requires the adaptation of modern technology to yield flexible, multifunctional products that are better, cheaper, and more intelligent than those currently on the shelf. The importance of mechatronics is evidenced by the myriad of smart products from washing machines to multifunctional precision machines [5, 10]. In a mechatronic system, the mechanical part has to perform certain motions and the electronic part and embedded computer system add intelligence to the systems. In the mechanical part of the system, power plays a major role. In the electronic part, information processing is the main issue. The sensors convert the mechanical motions into electrical signals where only the information content is important although a proper controller enables building a cheaper physical system, a badly designed physical system will never be able to give good performance by adding a sophisticated controller. Therefore, a proper choice be made with respect to the physical system properties needed to achieve a good performance of the controlled system [3, 8]. On the other hand, knowledge about the abilities of the controller to compensate for physical system imperfections may enable that a cheaper physical system be built. It is important that the modeling of physical systems is done in a way that the dominant physical parameters are preserved in the model and that the controller design can be done simultaneously. Good mechatronic system designs are based on a real systems approach [1, 2]. The details of the development of a mechatronics chest compression system for cardiopulmonary

resuscitation are presented in this paper. It is observed from the results that the control system developed in-house works well and regulates the functioning of the system as per AHA (American Heart Association) guidelines.

2. Development of an Electronic Control Unit

The design of the system follows a methodical approach. The microcontroller is the center of all activity and is essentially an interpreter between the input and the hardware peripherals. All the input data is sent to the microprocessor through input panel switches. And all output peripherals are connected to microcontroller with required electronics components like LCD display units. The requirements of AHA standards like compression depth, compression rate, and pause between the chest compressions are met by the system. The LCD indicator panel for continuous display of the above and is powered by 9V AC/DC adapter. After performing 30 compressions the microcontroller stops sending signals to the relay for the pause time which is generally for providing two rescue breaths, and then starts sending signals to the solenoid for chest compressions. Fig.1 shows the flowchart in which the program is written for Atmega16 micro controller using C++ embedded programming language and built in the control system [6].

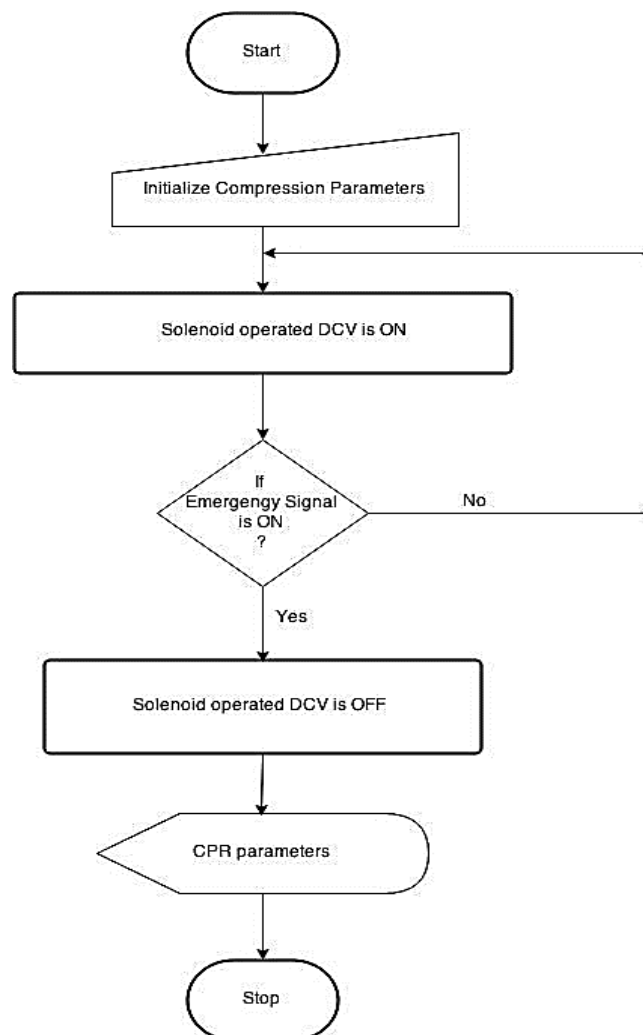


Figure 1: Flow chart

The microprocessor used for this work is the AVR ATMEGA16. It is a general purpose microcontroller with a variety of peripheral ports such as analog-to-digital converters (ADC), bidirectional TTL input/output ports, and a USART interface to allow RS232 serial communication. The original design of the embedded system hardware was to create a piece of hardware similar to a development board or kit. All of the basic oscillator, power, and programming components were implemented, and all output ports were connected to header connectors for ease of use during experiments and testing. Fig.2 shows the block diagram of the control unit and fig.3 shows the photograph of the hardware of the control unit developed.

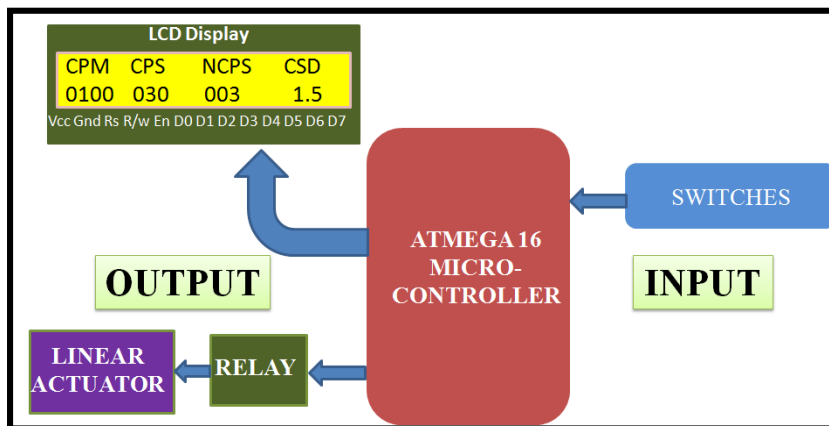


Figure 2: Block diagram of the control system

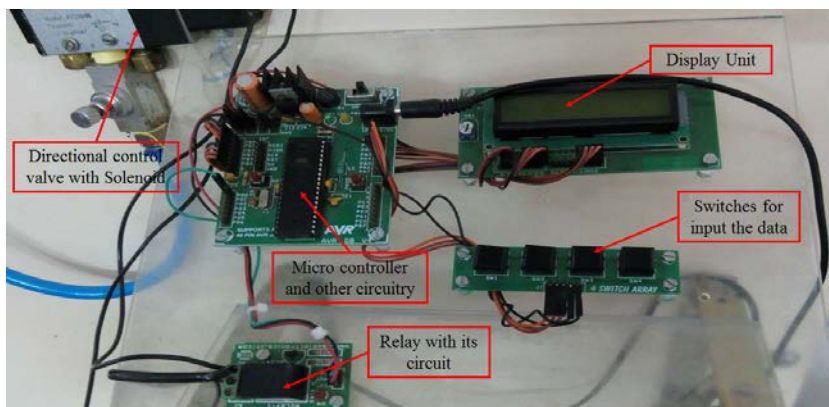


Figure 3: Photograph of a Electronic Control Unit (ECU) system

A veroboard prototype circuit was created as the final embedded software hardware. The circuit diagram in fig.4 depicts the final embedded system configuration. The microprocessor used is the AVR Atmega16 [6]. It was primarily chosen due to the following reasons:

- The development and programming interface of AVR Studio is easy to use.
- Atmega 32 is a mainstream processor and is compatible with many programmers
- Contains an adequate 16 Kbytes of flash memory

