Graphical User Interface for Arm Strength Training Machine

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Abstract - The realization of interactive communication between Arm Strength Training Machine (ASTM) and the users can make the training exercise and rehabilitation therapy become more convenient and realistic. In this article, we present a user-friendly Graphical User Interface (GUI) interface for an ASTM. The complete system consists of hardware implementation and software design, including a UART communication, an ADC converter, a microcontroller, and a permanent magnet synchronous motor (PMSM) drive for simulating the weight stack. The GUI interface is written in C language. Furthermore, the firmware of motor drive is designed based on the MPLAB development tool. To verify the feasibility and usefulness of the proposed method, the system is tested with different settings of desired torque and speed control to demonstrate its efficiency and convenience.

Keywords: Arm Strength Training Machine, Graphical User Interface

1 Introduction

Several conventional exercise apparatus, e.g. arm strength training machine, are usually coupled with a stack of iron weights through a series of pulleys and levels to hand grips [1-2]. Certainly, the user requires assistance with the experienced trainer or qualified rehabilitation therapist. However, the overall process always involves many time consuming stages to add or remove weights from the stack for efficient training and testing [3-4]. To resolve these problems, a permanent magnet synchronous motor is used to generate the opposition force for the user. As a result, a user-friendly interface for the arm strength training machine is realized to monitor the complete exercise cycle in real time situation. The framework of the system consists of a UART communication, ADC converter, personal computer, and a PMSM motor drive which is basically realized by a microcontroller for simulating the weight stack. The system software for human interface is developed under personal computer and written in C language. The rest of the paper is organized as follows. In section 2, the hardware configurations and the corresponding software descriptions of the arm strength training machine are discussed. Experimental results are demonstrated in section 3 and a conclusion is given in section 4.

2 Hardware Configurations and Software Descriptions

In the following, the complete framework of the proposed system is discussed in terms of hardware configurations and software descriptions, respectively.

A. Hardware Configurations

The hardware configurations mainly comprise two parts, as shown in Fig. 1. The first one is the ASTM which simulates the weight stack by using the PMSM motor drive. The second part is the human interface which provides an interface between the user and the ASTM. In Fig. 1, the dsPIC 30F4011 controller is the core part of the system. It is a 16-bit CPU with the capability of digital signal processing. The user can designate the desired instructions or commands, such as the desired speed or torque, to the ASTM by using the UART communication interface. The commands are then processed by the dsPIC digital signal controller. The dsPIC digital signal controllers provide designers with an easy upgrade path from 8-bit PIC microcontrollers and a cost effective option to 32-bit MCUs. Combined with hardware and free software, these 16-bit products are ideal for designs including high efficiency motor control. Thus, the dsPIC controller then generates the proper sinusoidal pulse width modulation (SPWM) signal to control the output of inverter in such a way to obtain the adequate motor torque according to the input command. Consequently, the speed, current, and encoder signals, are sensed and processed further. Therefore, the applied force and speed rate that the user currently exerts can be displayed on the human interface in real time condition.

Moreover, the built-in PWM module, addressable encoder interface module, and input capture module, can make the design become more efficient. The motor currents are also sensed through the current detection circuit. The magnet pole and rotor position are detected by the Hall effect sensor and the encoder.

B. Software Descriptions

The system software for human interface, including the serial communication protocol, is developed in C language. The firmware of motor drive is written and tested, based on the MPLAB development tool. The MPLAB Starter Kit for

dsPIC Digital Signal Controllers is a complete hardware and software tool suite for exploring applications based upon Microchip's dsPIC DSCs. The block diagram of the developed software is illustrated in Fig. 2.

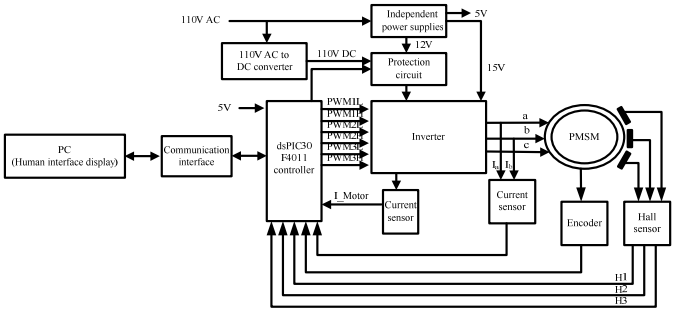

Fig. 1. The hardware configurations of the ASTM.

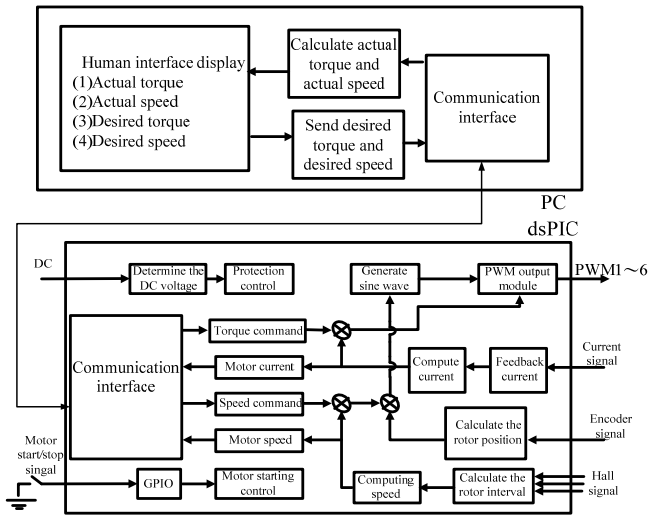

Fig. 2. The software descriptions of the ASTM.

The GUI interface is also designed to facilitate the operational commands to ASTM. Thus, the communication between them is very critical. In this paper, the actual torque and motor speed are received by the UART controller through the communication interface. Then, the SPWM technique is applied to drive the thee-phase inverter. Since the resolution of encoder is 2,500 pulses per revolution, the value of the counter in the microcontroller will be 5,000 counts. Because the sinusoidal waveform is symmetric for 0^o to 180^o, only the sine values of 0^o to 90^o are created which covers the 312 counts of encoder for a 8-pole rotor.

3 Experimental Results

The GUI interface for the arm strength training machine is tested by giving desired commands to verify its functions and correctness. In this experiment, the desired torque is 10 kg-cm and the desired speed control is 10 cm/sec. During operations of manipulating the ASTM, the actual torque and actual speed of the user exercising are correctly demonstrated in the GUI, as shown in Fig. 3.

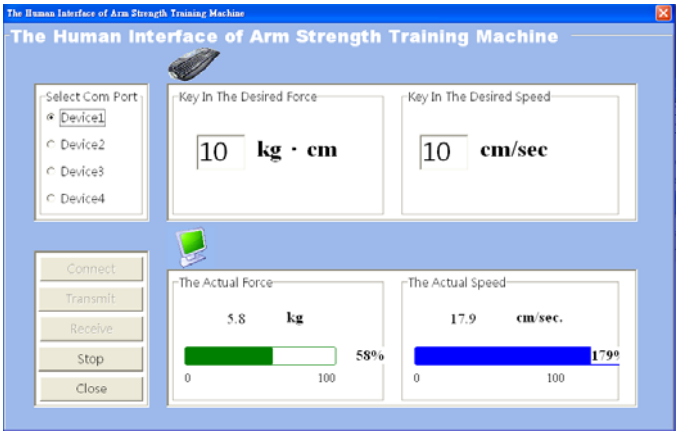

Fig. 3. The actual values displayed in human interface, Torque:10 kg-cm, Speed:10 cm/s.

4 Conclusions

In this paper, the implementation of a GUI interface for the arm strength training machine, based on the dsPIC controller, is realized and demonstrated. Without assistance of professional trainer or qualified rehabilitation therapist, the proposed system provides a user-friendly interface and can also facilitate the exercise for the users.

Acknowledgment

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