LabVIEW Application for Motion Control Using an Embedded 3.5 Inch Single Board Computer

by:
H. Lehnich, G. Kaltenborn, H. D. Pauer
Martin-Luther-University Halle-Wittenberg; Medical Department ;
Centre of Medical Basic Research

Category:
Biomedical

Products Used:
LabVIEW™ 6*i*

Figure: 1 Control device for the cone and plate apparatus in standalone mode

The Challenge: Development of a control device for a cone and plate apparatus to apply dynamic shear stress to endothelial cells.

The Solution: A 3.5 in. single board computer (SBC) was embedded into the control device to get PC functionality and the ability to use a LabVIEW application as firmware (Figure 1).

Introduction

In vitro cell shearing devices based on the principles of a cone and plate viscometer are used to investigate the functional and structural responses of endothelial cell cultures to applied shear stress. The generated shear stress depends on the viscosity of the fluid the cells are covered with, the angle of the cone and its rotating speed. The easiest way to perform dynamically shear stress is to control the cone velocity, according to a user defined input waveform (shear stress-time diagram). Therefore the control device has to offer two several modes: define and test the waveform and execute the motion.

System Software

LabVIEW offers an easy to use interactive user interface, in version 6*i* the new wave form data type and reduced disk and memory requirements in comparison with version 5.1. On the other hand highly integrated low power SBC equipped with solid state hard disks (usually 32-64 Mbytes) are now available in a size of a 3.5 in. floppy disk. Combining the SBC and LabVIEW and embedding them into the control device makes it possible to the manufacture to build the firmware in a graphical way. The user also takes advantage of the graphical user interface. Connecting monitor, keyboard and mouse to the embedded SBC (PC mode), a VI supports him to create the shear stress – time diagram (user defined input wave form). The program calculates the cone velocity waveform due to the shear stress – time diagram and saves it to the solid-state disk. Additionally the user can test the created files and manage them, using the operating system. In standalone mode an alphanumerical LCD terminal replaces the graphical user interface. It shows the names of the created files and the user can select and execute them with the help of two push buttons. According to the waveform, the required motor speed or the direction will be changed continuously by the LabVIEW executable.

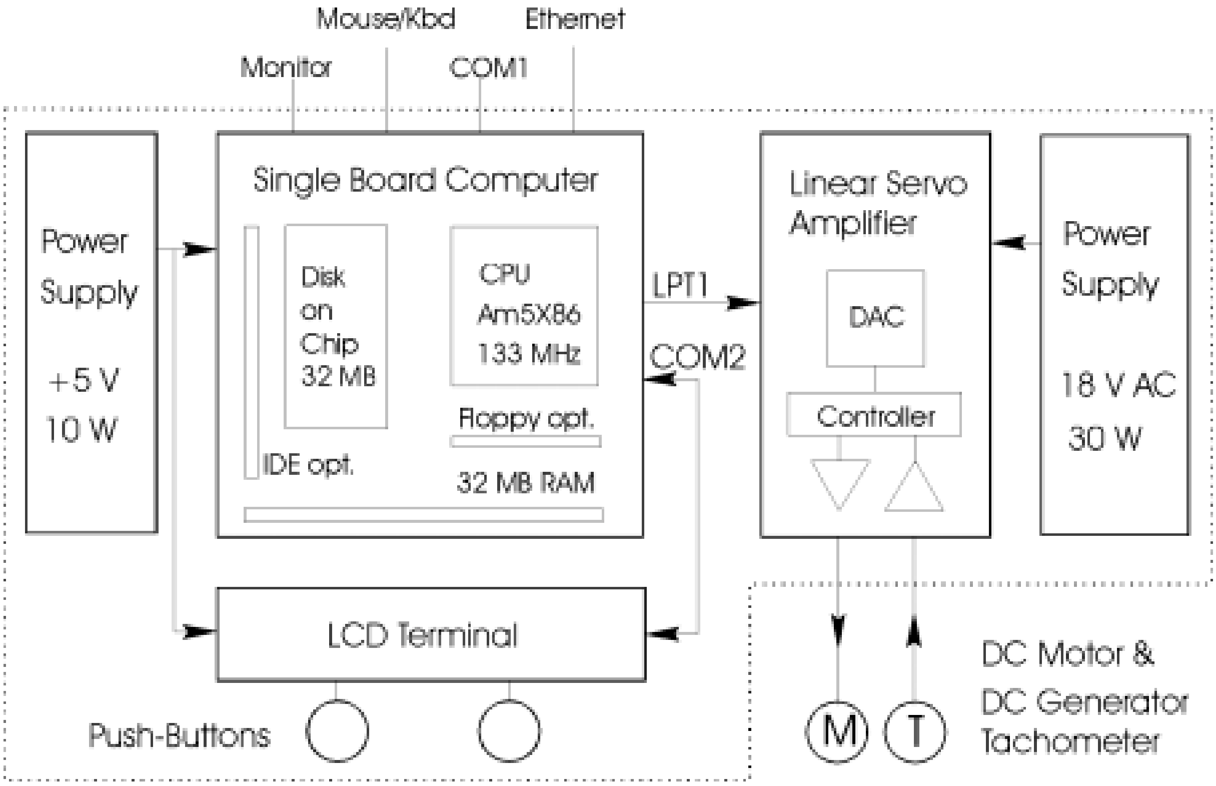

Figure: 2 Hardware overview

System Hardware

Analogue – The DC generator tachometer measures the speed of the cone, producing a positive or negative voltage depending of the direction. The linear servo amplifier compares it with the set point, provided by the digital analogue converter (DAC) and controls the voltage to the DC motor (analogue control loop). If the set point is dynamically changed by the SBC, the cone follows the user-defined motion. Using a DC motor & generator driving system, sinusoidal alterations up to one Hz are executable. For higher frequencies micro stepper motor technology is required.

Digital – In standalone mode the user dialogue is performed bi-directionally by the LCD terminal via COM2. The received alphanumerical characters (escape sequences) are displayed and if one of the buttons is pushed, the terminal sends the accompanying code to the SBC. The parallel port connects the SBC and the DAC uni-directionally to set the required motor speed. The connectors for monitor, keyboard, mouse and network, used in PC mode, are located on the edge of the SBC to be easily accessible at the backside of the control device.
The basic components of the SBC are the low power CPU, a standard RAM module and a Disk on Chip 2000 (DOC) flash hard drive. The IDE and floppy interfaces are necessary to load the image of the operating system and the firmware (LabVIEW application) to the DOC.

Operating System

The available disk space is restricted on expensive flash hard drives. For this example, the 32 Mbytes DOC should contain a 32-bit operating system, the LabVIEW run time DLL (4 Mbytes), the LabVIEW application (1 Mbytes) and data space (1 Mbytes). Because of the 32 Mbytes RAM there is no need to reserve virtual memory. Therefore 26 Mbytes are left to the operating system (OS). Using a Windows OS, either the NT embedded toolkit or a minimised Windows 95 can be used to create the desired OS image. The NI Developer Zone describes the procedure using embedded NT. The benefit of using the second method is to run the same OS on the development PC and the target SBC, only in a different size. To design the small OS image, the following steps are necessary. A CD-ROM and an ordinary hard disk are temporarily connected to the SBC. Windows should be installed without any additions to the hard disk. By stripping away facilities step by step that are not required for the target system (i.e. multimedia, OLE, help, fonts, inf), Windows shrinks to the desired size. The functioning image is copied to the DOC. Removing the IDE devices, Windows boots from the DOC.

Conclusion and Preview

The described solution combining an embedded SBC and LabVIEW is suitable for other standalone or networked devices. Increasing the DOC makes it possible to install the NI-DAQ software and PCMCIA data acquisition cards. This results in a basic hardware configuration. The properties of the particular device are then fixed by LabVIEW. The software is the instrument.

Contact holger.lehnich@medizin.uni-halle.de