DSP-BASED CONTROL OF A SERVOPNEUMATIC POSITIONING SYSTEM

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ABSTRACT

One of the challenging problems in the field of robot control is how to make a robot manipulator to move as fast as possible without violating the accuracy requirements.The most wideliy used controller is stil the PID (proportional, integral, derivative) controller because of its simplicity and ease of implementation, but it is'nt good for nonlinear systems with parameters and load variations. In this work, a DSP-based sliding mode controller is implemented and described. Digital Signal Processing (DSP) is one of the most powerful technologies int he twenty-first century, that will bring revolutionary changes in the field of control too.

1. INTRODUCTION

This paper presents a high speed digital signal processor (DSP) based servopneumatic positioning system control. Motion control systems are generally designed to move a load along a specified path as fast as possible without damaging the load or the mechanism driving it. The main disadvantages of pneumatic servo systems are that they are inherently non-linear. A pneumatic servo system contains several nonlinearities such as a non-linear air flow-pressure relationship through the variable area orifice of the servo valve, the compressibility of air, the nonlinear friction between the contacting surfaces of the slider-piston system. Those nonlinearities cause significant time delays, overshoot and profile-following errors in the system's dynamic responses. The aim of this research is to improve the positioning accuracy of servopneumatic positioning systems.

2. THE SERVOPNEUMATIC POSITIONING SYSTEM

As an important driving element, the pneumatic cylinder is widely used in industrial applications for many automation purposes thanks to their variety of advantages, such as: simple, clean, low cost, high speed, high power to weight ratio, easy maintenance, inherent compliance. Due to the substantial nonlinearities, early use of pneumatic actuators were limited to simple applications that required only positioning at the two ends of the stroke. It consists of a double-acting pneumatic rodless cylinder (MECMAN 170 typ.) with bore of 32 mm, and a stroke of 500 mm, controlled by a five-way servo-distributor (FESTO MPYE-5-1/8 LF-420B tip.). A linear encoder (LINIMIK MSA 320 tip.) gives the position. Velocity and acceleration are obtained by numerical derivation. Presure sensors are set in each chamber. The DSP is responsible for gathering information about the piston position. It gets data from each peripheral sensors, processes that data, and sends the control signal to the servo-distributor. The system under consideration is shown in Fig. 1.

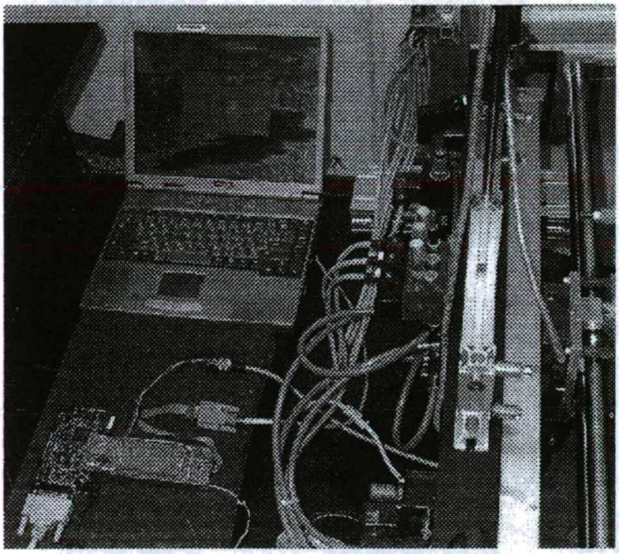

Fig. 1. The experimental positioning sysem

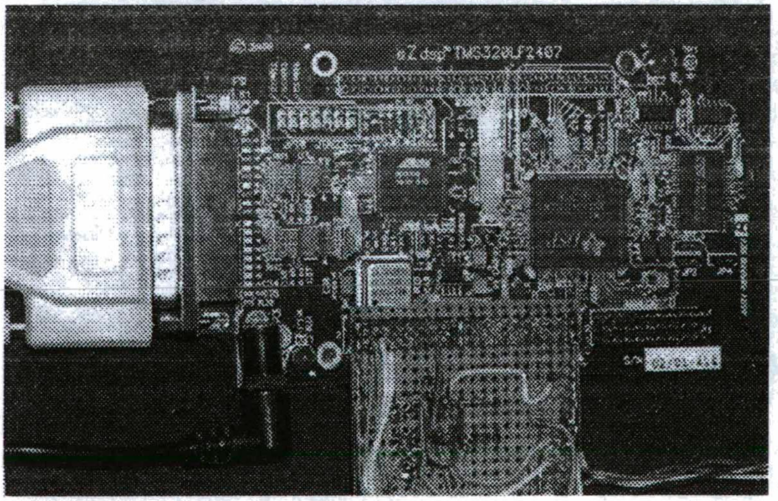

Fig. 2. DSP target board

3. DSP BASED SLIDING MODE CONTROL

DSPs are designed for signal processing and have hardware optimizations which are directly applicable to digital control. On the Fig. 2. we can see the „eZdspTM for TMS320LF2407" DSP target board from Spectrum Digital. The DSP Starter Kit (DSK) enables the user to connect the DSP to the parallel port on a PC and download code using a

DOS interface. This interface allows the programmer to step through the code on the DSP and check the values of registers and memory locations while debugging.

Hardware Features

- ✓ TMS320LF2407A Digital Signal Processor operating at 40 Mhz from Texas Instruments
- ✓ Communications to host PC via parallel port for debug and communications
- ✓ 64K words of zero wait state memory (32K program, 32K data)
- ✓ Embedded IEEE 1149.1 JTAG scan controller
- ✓ Expansion connectors for custom user logic (data, address, I/O)

Software Features

- ✓ Compatible with C2000 Code Composer from Texas Instruments
- ✓ Compatible with SDFlash programming utility from Spectrum Digital

The control algorithm is written in "C" language, and compiled into assembly language and downloaded into the DSP board.

The pneumatic servosystem is a very nonlinear time-variant control system because of the compressibility of air, the friction force between the piston and the cylinder, air mass flow rate through the servovalve, etc. The sliding mode control theory was used to solve the model imprecision problem and also widely applied in nonlinear control.

Fig.3. The Controller Operating Window

4. EXPERIMENTAL RESULTS

In the following experimental result, the system pressure is set to be 5 bar, the sampling time is 2 ms. In order to analise the positioning methods a real-time data acquisition program was designed for a PC to capture the system output data through the communication interface between the PC and the DSP controller. The control program are in the DSP program memory. So the DSP controller can operate independently. Since the DSP has a fast operation speed and a large memory, it can be employed in the control loop to increase the sampling frequency and the control accuracy.The position error of the DSP based sliding mode control is within 0.01 mm. A DSP-based sliding mode control system results very satisfactory performance.(Fig. 4. Fig. 5.)

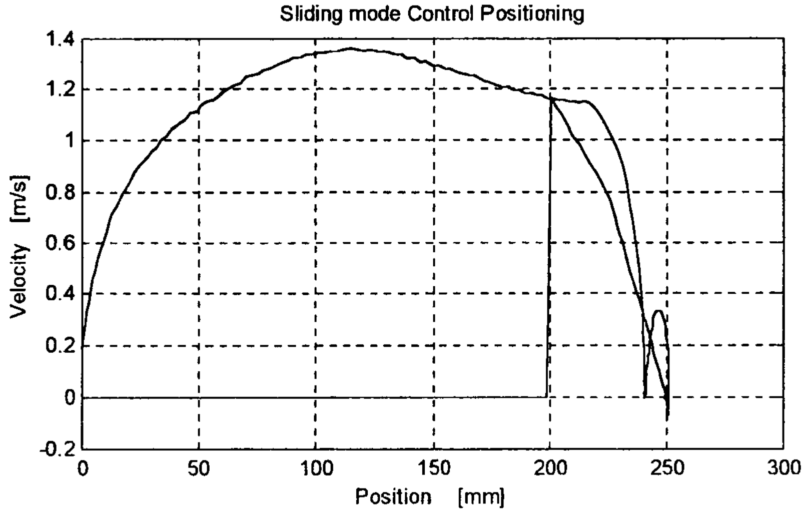

Fig. 4. Phase plane trajectories

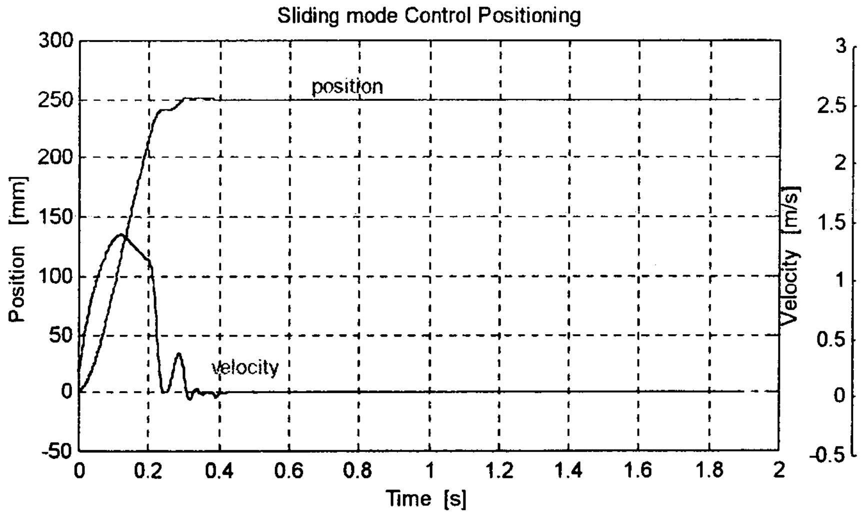

Fig. 5. Positioning results

5. FUTURE WORK

We can make the conclusion, that the DSP based sliding mode controller is sutable and effective for the position control.
Furthermore we interested in trying out all methods on "real world" systems. So we have created a pneumatic test stand, as shown in Fig. 1. and we will compare the simulation results to experimental results.

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