Multi Axes Motion Control System using Ping Pong Buffers with Vibration Analysis

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Abstract

This article presents a novel motion control system with multiple axes using an Ethernet link from a host generating the motion profile and the motor drivers/ controllers. To implement an architecture which can deliver jitter free trajectory scalable to 18 axes at an update rate of 5KHz. While analysis and trajectory generation are performed for 6 axes control, motor control is evaluated on a mechanical system with two motors. The aim is to achieve efficient motion control with jerk free motion. The algorithm uses ping pong buffers to load and run the motors. Comparisons are made based on the results obtained using various DSP controllers. The motion profile of a circle is experimented and discussed in this article.

Keywords: Motion control, Ethernet, Vibration analysis, DSP controllers.

Introduction

Motion control system's purpose is to control anyone or the combination of the following parameters: Position, velocity, acceleration and torque. Velocity control needs to be quantified with respect to several issues like what is the speed required to do the application. Torque control suggests the need to control the torque or force in a system independent of speed. Position control entails the control of motion displacement which is the change of motion with respect to time. This includes command, control and the monitoring of motion. The acceleration rate will affect the force in the system since torque is the product of inertia and acceleration rate. Position control requires flexibility regarding the need to change certain parameters of the required motion. Motion planning computes a collision-free and continuous path from the initial point to the destination point. Motion planning is breaking down a desired path into discrete motions. Smaller the distance between two movements smoother will be the curve. The objective of a path planning is to dynamically create a path position reference for the control movement from initial point to destination point.

Motion Profile Path

A path is describes in terms of X and X' such that:

X = [x0 x1] and X'=[x0' x1']

Where X is the displacement (position) and X' is the velocity; It can be noted that for finer values of x0, the smoother will be the motion. At this time acceleration control is not envisaged and hence not considered in the computation. The idea is to compute X and X' continuously and pipe to the controller/ drive continuously. Profile path is created and the motion commands are fed through the Ethernet into the controller and interfaced to the drive.

The path is created by feeding the values to software. This path is then divided into various slots of motion considering the speed and the steps. Path will be traced considering the position and velocity at different points of time.

Motion Control

The motion control is experimented using a profile of a circle. The profile is created by using the software and the motion points are fed to the

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ping pong buffers. Ping pong buffers are two different buffers that load the values of the motion alternately. The ping buffer fills with the direction, speed and the steps of the motion and runs. By the time the ping buffer runs, pong starts filling the values and pong runs. Again when the pong runs the ping starts filling the values. Thus the filling of the buffers and running of the axes goes on alternately.

Block Diagram

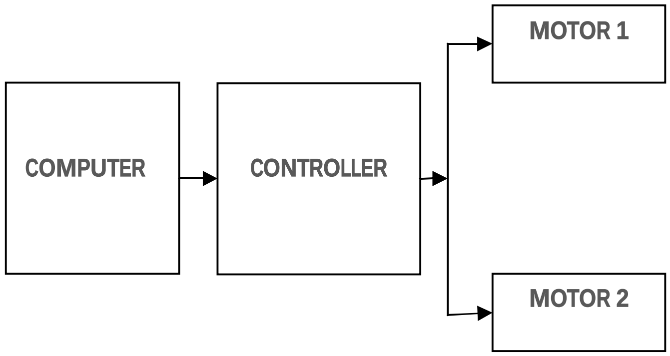


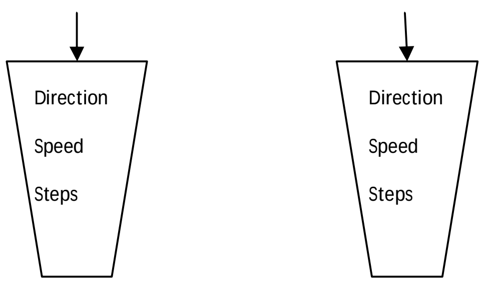
Figure 1.Block Interfacing of Control System

The PC side consists of the UDP data sending and receiving application. It is interfaced with the controller by using debugging or the programming slot from the controller to the PC.

Also the Ethernet is connected to the PC from the controller board. On the other side of the controller, the motors are connected to it via the drivers.

Algorithm

Step 1: Load the ping buffer with the data, direction, speed, steps.
Step 2: Run the ping buffer.
Step 3: Load the pong buffer with the data, direction, speed, steps during ping runs.
Step 4: Run the pong buffer.
Step 5: The axes starts running as soon as the data in the buffers start filling.



Fills ping when pong runs Fills pong when ping runs

Experiment

The SC04 board with the controller MCS9845 is used. The MCS9845 is a PCI based dual-channel high performance UART plus a PCI to ISA bridge. The board is connected to the motors using drive. The vibration analysis is done and the result is recorded.

Similar experimental setup is carried for the TIVA TM1294NCPDT [6] controller and the vibration results are recorded.

Figure 2.Experimental Setup

Vibration Analysis

A circle of 10mm radius is loaded into the controller. The parameters loaded are the speed and the steps required for the total movement. These parameters are fed in a queue to the controller. Motors were tested at various speeds. The analysis of the smoothness of the motors was done using Vibration sensors.

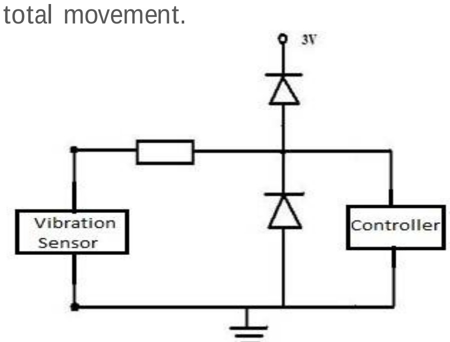
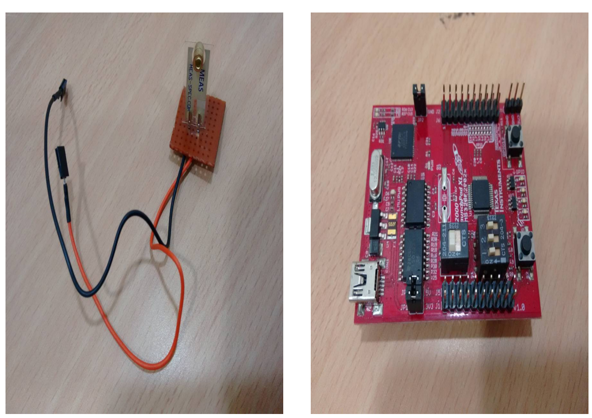


Figure 3.Protection circuit

The sensors [4] were mounted on the motors and tested. A protection circuit is connected between the sensor and the controller. The vibrations of the motor were recorded and stored. The controller used for ADC is TMS320F28069 [5] which has a 12 bit ADC. A total of 512 samples were taken and recorded as voltages (0-3.3V). RMS of these values at different speeds is found.



Vibration Sensor **TMS320F28069**

Figure 4.Vibration sensor and Controller used

Result

The recorded result of the SC04 controller is as follows:

TIVA controller TM4C1294NCPDT	
Speed	**RMS value**
200	0.113
600	0.0694
700	0.0599
800	0.0584
1000	0.0572

Table 1.Recorded result of SC04 controller

The RMS value decreases as the speed increases. The vibration at a minimum speed is found to be the largest.

The next experiment was done on the TIVA TM4C129NCPDT by Texas Instruments which operates at 120MHz.

SC04 controller MCS9845	
Speed	**RMS value**
200	1.0587
600	0.9302
700	0.9043
800	0.8664
1000	0.5543

Table 2.Recorded result of TIVA controller

The results clearly show that the vibrations of the motor are very less than SC04 controller. At a speed of 1000 the RMS value is as small as 0.0572.

Conclusion

This article describes the development of a motion control system using ping pong buffers. A motion profile is fed to the controller that delivers a smooth and efficient movement of the motors. The motion profile tested was a circle of 10mm radius. The motion profile was tested on two DPS based motion controllers. Vibration analysis was done and the best smoothness and accuracy was observed in Texas Instruments TIVA129 controller.

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