Synthesis of the 3D Linux-Based CNC System for Precision Machines

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Abstract
This paper proposes a design methodology for a Linux based CNC control system with open architecture capabilities. The developed Linux-based CNC system consists of several software modules such as NCK, PLC, and MMI modules as well as I/O devices. These modules and basic I/O devices are integrated on a single processor platform. In order to verify the performance of the developed system, linear and circular motion errors are measured according to operating conditions in a precision x-y positioning system. In addition, the developed CNC system is applied to a horizontal arm-type CMM with a jerk-limited linear interpolator.

Keywords: Contour Error, Jerk-limited Linear Interpolator, Linux system, NCK, Open-Architecture Controller, PC based CNC, Real-Time Kernel

1. Introduction
Most CNC systems have been developed as a closed architecture and supported by the proprietary technology. Owing to the lack of openness in controllers used today, developers are commonly confronted with closed and proprietary CNC functions. It is virtually impossible to incorporate different types of controllers and sensor-based control schemes [1,2]. Therefore, a Linux based CNC control system with open architecture capabilities is studied to reduce the limitations in this paper.

The Linux based CNC kernel consists of several software modules on a single processor platform so that particular kernel modules can be easily added to and/or removed from the Linux kernel dynamically. The developed CNC system can be integrated with several other functions so as to realize an intelligent CNC system.

Two control schemes are used in the developed Linux-based CNC system. The first control scheme is a cross-coupling control (CCC) scheme to reduce contour error in two-dimensional motion [3]. The second one is a linear interpolator which employs jerk-limited acceleration profiles for preventing structural vibrations and increasing positioning accuracy in a horizontal arm-type coordinate measuring machine [4].

2. Architectures of Linux-based CNC system
A Linux-based CNC system based on the software PC-NC [1] is designed to utilize the PC hardware as shown in Fig. 1. Many advantages of PC systems can be incorporated in the developed system. The real-time task is executed in modules potted in the real-time Linux kernel. Many tasks performing various control functions are constructed for the Linux-based CNC system.

3. Design of CNC module
Since Linux and RT-Linux operating systems have open source codes, small-occupied memory size of the real-time kernels, stability and low latency characteristics, as well as free availability, a CNC platform is constructed by using them. Real-time tasks may have higher priorities compared to the Linux kernel, and may preempt it in order to meet deadline requirement.[5] A GTK+ language is used to develop MMI modules. Various control modules are written in C-language.

Fig. 1 Architecture of Linux-based CNC system.