

USB File Handling System for CNC Machine using Dual Core DSP Processor

Nisha R. Gosavi

Department of Electronics &
Telecommunication
K. K. Wagh Institute of
Engineering
Nashik, India

Sunil S. Morade

Department of Electronics &
Telecommunication
K. K. Wagh Institute of
Engineering
Nashik, India

Dipankar D. Khartad

Department of Electronics &
Telecommunication
K. K. Wagh Institute of
Engineering
Nashik, India

ABSTRACT—Precisely programmed commands encoded on a storage medium are used for automation of machine tools in the Computer Numeric Control (CNC) machines. End to end component design is highly automated using DSP processor in the modern CNC systems. The use of RS232 for serial communication became inefficient now a days where fast processing is required. RS232 communication is slower in terms of speed compared to USB communication so it is efficient to use USB communication for CNC to continuously work with the system. In USB communication number of devices can be connected by using USB hub but using RS232 only one device can be connected at a time. In this experiment the dual-core DSP microprocessor TMS320F28377D is used for fast and precise operation. The processor has USB 2.0 slot so it becomes easy to develop a FAT32 file management system for CNC machine using USB 2.0 flash drive.

Keywords— CNC, USB, Dual Core, FAT32, File Management.

I. INTRODUCTION

CNC technology can produce complicated and precise components used for different purposes. It can also reduce the operative difficulty and time of machine tools while improving the work efficiency. CNC is one in which the functions and motions of a machine tool are controlled by means of a prepared program containing coded alphanumeric data. CNC can control the motions of the workpiece or tool, the input parameters such as feed, depth of cut, speed, and the functions such as turning spindle on/off, turning coolant on/off [1].

A CNC system consists of three basic components: a part program, Machine Control Unit (MCU) and a machine tool (lathe, drill press, milling machine etc). Fig 1 shows the axis of CNC machine

according to which different shaped tools can be manufactured [2].

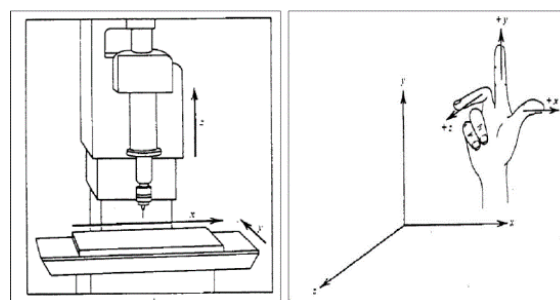


Fig. 1 Axis of CNC machine

The TMS320F28377D is a powerful 32-bit floating-point microcontroller unit (MCU) designed for advanced closed-loop control applications such as industrial drives and servo motor control, solar inverters and converters, transportation and power line communications. This processor is mainly designed for the motor control applications and other high end applications. The F2837xD supports a new dual-core C28x architecture [11].

The dual real-time control subsystems are based on TI's 32-bit floating-point CPUs, which provide 200 MHz of signal processing performance in each core. The new Trigonometric Math Unit (TMU) accelerator enables fast execution of algorithms with trigonometric operations common in transforms and torque loop calculations; and the Viterbi Complex Math Unit (VCU) accelerator reduces the time for complex math operations common in encoded applications. The USB 2.0 port lets users easily add universal serial bus (USB) connectivity to their application [12].

Real-time control systems that operate on USB peripheral devices have become more common because the USB interface eases the task of installation with plug and play. USB makes the connection of peripheral devices to the control card easier, more efficient and hence addresses simple I/O. By using USB there is no need to connect the laptop or PC to the CNC system [10].

II. SYSTEM OVERVIEW

A. Universal Serial Bus (USB)

Universal Serial Bus communication is based on master slave relationship between host computer and device as shown in fig. Slave responds to master's requests and there can be only one master and can be no. of slaves in the system [3]. Also, USB devices cannot interact with each other without host (Master). USB system software consists of USB driver and host controller driver for proper USB communication which are explained in Fig. 2 as below [4].

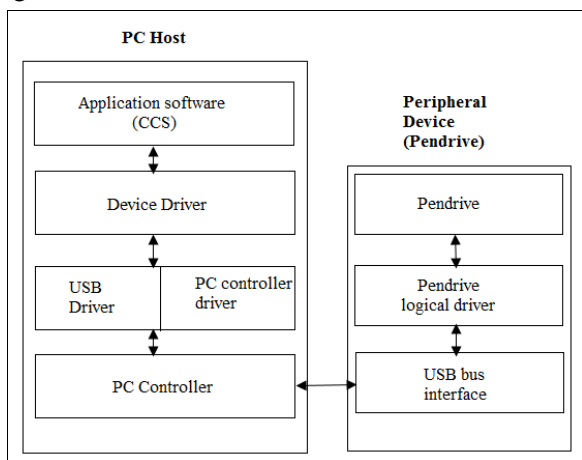


Fig. 2 USB Communication

1) Address/Data Bus Bridge

The USB controller on this device is the controller that is on the stellaris devices. This controller was originally designed to connect to an ARM AHB bus, but has been modified to function with the C28x device's bus architecture. The modifications made are invisible to the user application, but some things can be noted. [11]

- The USB memory space is 8 bits wide, while the DSP C28x memory space is 16 bits wide.
- 32 and 16 bit accesses (r/w) are completely transparent to the user application code so no need of any change.

- Only 8 bit accesses through a byte intrinsic type is supported by The C28x core. This can be used to perform 8 bit reads or 8 bit writes to the USB controller.

B. File System

Different types of file systems are available for different devices for the file operations. e.g. NTFS, FAT12, UDF, exFAT, FAT16, FAT32. File Allocation Table (FAT) is a computer file system architecture and a family of the industry-standard file systems utilizing it. It is supported for compatibility reasons by the all currently developed operating systems for personal computers and many mobile devices and other embedded devices, and thus is a well-suited format for data exchange between computers and devices of almost any type and age from 1981 up to the present. Three major FAT file system variants are: FAT12, FAT16 and FAT32. FAT32 file systems are commonly found on floppy disks, USB sticks, flash drives and other solid-state memory cards and modules, and many portable and embedded devices [5].

III. SYSTEM DESIGN

In this experiment the dual core DSP processor TMS320F28376D is used for fast processing. This processor has the USB slot and SDcard slot so that any type of file to the machine can be given by the USB instead of RS232 as shown in Fig. 3 [11]. The internal system will process the file according to the program written and then convert it into the .kou file with some changes in original file as shown in Fig 4.

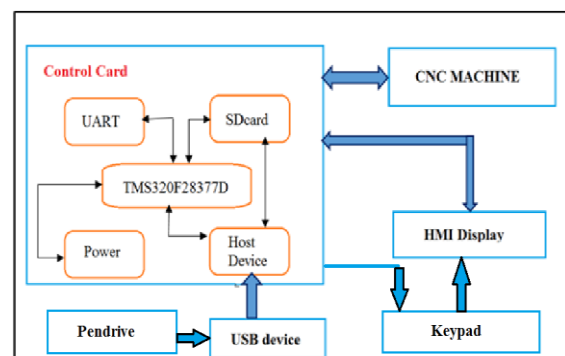


Fig. 3 Block diagram of the system

This experiment implements FAT-32 file system for the CNC which includes the functions such as creating the new file into USB, copy the contents of the file, reading the file, write into the file, deleting the file from USB and many more functions [5]

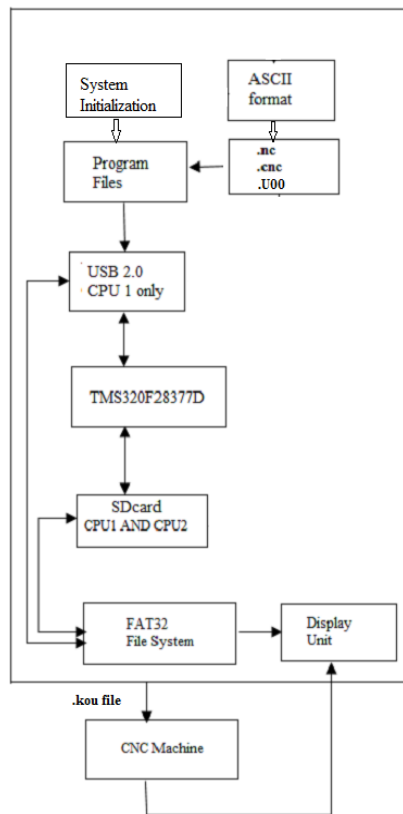


Fig. 4 Flowchart of the System

A. Hardware Design

The Delfino F28377D controlCARD from Texas Instruments is ready and an ideal product for initial software development as shown in Fig. 5 [13].



Fig. 5 TI's F28377D ControlCard

It is the short run builds for embedded system prototypes, test stands, and many other projects that require easy access to high-performance controllers to increase system performance [12].

The host system needs to provide only a single 5V power rail to the TI's controlCARD for it to be fully functional. Fig 6 shows the interfacing of USB to the controlCARD and the control card connected to PC system.

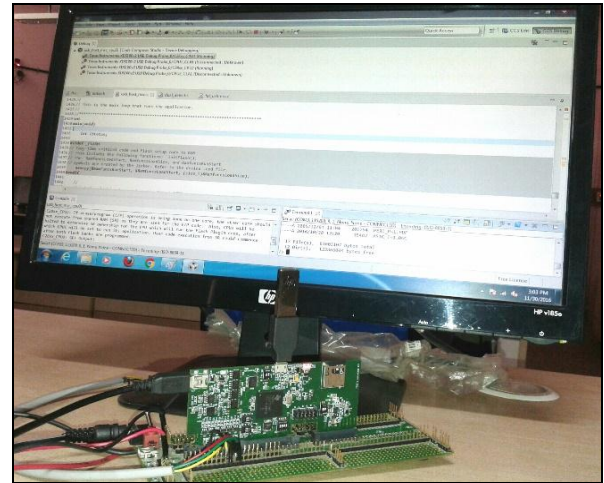


Fig. 6 USB interfacing to control card

B. Software Design

In this experiment the text file will be taken from USB and then the file will be processed and then converted to .kou file with some changes in original file. Also the experiment is concentrated to make the FAT32 file management system for CNC system using USB flash drive and eliminating the use of RS232. The processing step of the file will be displayed on graphical display.

Code Composer Studio (CCS) is an integrated development environment (IDE) by Texas Instruments (TI) for embedded processor families. CCS comprises a suite of tools used to develop embedded applications as shown in Fig. 7. It includes compilers for each of TI's device families, source code editor, project build environment, debugger, profiler, simulators, real-time operating system and many other features needed to develop an embedded system. The intuitive IDE provides a single user interface through each step of the application development flow [12].

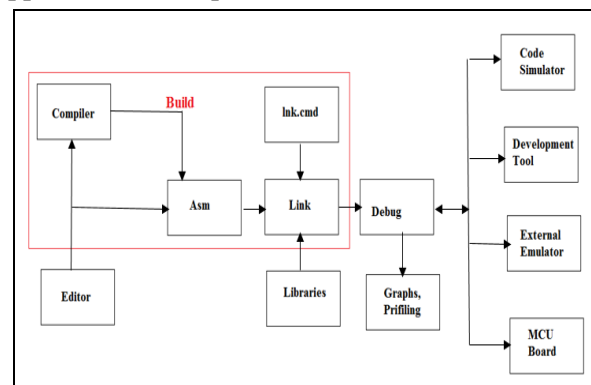


Fig. 7 Software development flow

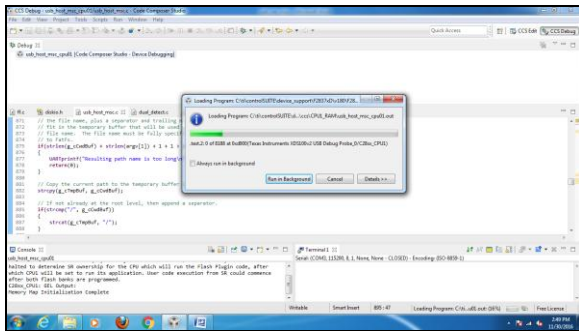


Fig. 8 CCS edit and debug window

USB can access the memory of Code Composer Studio as per its requirement based on the application system. Table 1 shows the memory access of the USB from CCS.[11]

Table 1 Memory access of USB from CCS

CCS 32 Bit	
Address	Displayed Data
0x00	0x11001100
0x02	0x33223322
0x04	0x55445544
0x06	0x77667766
0x08	0x99889988
0x0A	0xBBAABBA
0x0C	0xDDCCDDCC
0x0E	0xFFFFFEE

IV.CONCLUSION

In this experiment it is noted that the dual core DSP microcontroller TMS320F28376D helps to achieve fast processing and gives precise output. As the file to the system is given by USB instead of RS232, there is no need to connect the laptop to the CNC system. It will also help to achieve the faster transfer rate. Use of USB reduces the processing time because the next instruction will be fetch while the previous one is in execution. This is not possible using RS232 the speed of RS232 is very low compared to the speed of USB . One of the advantage of this experimental work is that system will not require any extra memory as we are working on USB flash drive. In this experiment Peripheral Interrupts are efficiently used to avoid polling mode operations and to reduce the processing time as it works using dual core.

USB makes the connection of peripheral devices to the control card easy ,effective and more efficient and hence addresses simple I/O. Better bandwidth reservation and scheduling algorithms have been used in this experiment that guarantee Quality of Service with USB communication to support real-

time requirements. Code Composer Studio helps to efficiently and effectively implement the system.

V. FUTURE SCOPE

TMS320F28377D is a dual DSP core processor so it can be used in the systems where fast and precise execution is must. This processor will be more efficient and effective for industrial drives, motor applications and other power electronic applications as well as embedded systems. USB 3.0 flash drive will be used in combination with this processor to achieve faster transfer rate in future. SDcard interfacing for the applications based on the external memory will be easily done. Also using the control card of TMS320F28377D we can detect that whether the USB is acting as a host or acting as device where laptop or PC system is also connected to CNC system along with the control card.

REFERENCES

- [1] Hanmin Ye and Qianting Sun, "Design of CNC system for electrical discharge machining based on DSP," 2014 IEEE Workshop on Advanced Research and Technology in Industry Applications (WARTIA), Ottawa, ON, 2014, pp. 797-800
- [2] G. Calderon-Lopez, A. Villarruel-Parra, P. Kakosimos, S. K. Ki, R. Todd and A. J. Forsyth, "A comparison of digital PWM control strategies for high power interleaved DC-DC converters," 8th IET International Conference on Power Electronics, Machines and Drives (PEMD 2016), Glasgow, 2016, pp. 1-6.
- [3] E. Missimer, Y. Li and R. West, "Real-time USB communication in the Quest operating system," 2013 IEEE 19th Real-Time and Embedded Technology and Applications Symposium (RTAS), Philadelphia, PA, 2013, pp. 11-20.
- [4] Y. Xin, "Hardware and Software Design between Microcontroller and Computer Based on USB Interface," 2014 Fifth International Conference on Intelligent Systems Design and Engineering Applications, Hunan, 2014, pp. 520-523.
- [5] O. Mahendra, D. Syamsi, A. Ramdan and M. Astrid, "Design and implementation of data storage system using USB flash drive in a microcontroller based data logger," 2015 International Conference on Automation, Cognitive Science, Optics, Micro Electro-Mechanical System, and Information Technology (ICACOMIT), Bandung, 2015, pp. 58-62.
- [6] S. Zhang, T. Fan and X. Wen, "Hardware Design of a Permanent Magnet Synchronous Motor Control

- Circuit," *2016 IEEE Vehicle Power and Propulsion Conference (VPPC)*, Hangzhou, 2016, pp. 1-4.
- [7] G. G. Talapur, H. M. Suryawanshi, A. B. Shitole, S. Sathyan and V. V. Reddy, "Performance improvement of digital variable band hysteresis current control using dual processor microcontroller," *IECON 2016 - 42nd Annual Conference of the IEEE Industrial Electronics Society*, Florence, 2016, pp. 2367-2371.
- [8] F. Barbieri, R. P. S. Chandrasena, F. Shahnia, S. Rajakaruna and A. Ghosh, "Application notes and recommendations on using TMS320F28335 digital Signal Processor to control voltage source converters," *2014 Australasian Universities Power Engineering Conference (AUPEC)*, Perth, WA, 2014, pp. 1-7
- [9] H. Fu, C. Li and Y. Fu, "A Parallel CNC System Architecture Based on Symmetric Multi-processor," *2016 Sixth International Conference on Instrumentation & Measurement, Computer, Communication and Control (IMCCC)*, Harbin, 2016, pp. 634-637
- [10] L. Ramadoss and J. Y. Hung, "A study on universal serial bus latency in a real-time control system," *2008 34th Annual Conference of IEEE Industrial Electronics*, Orlando, FL, 2008, pp. 67-72.
- [11] S. S. Morade, S. P. Ugale, D. M. Chandwadkar "Implementation of DSP based CNC machine supporting card for interfacing high & low speed peripherals" *International Conference on Systemics, Cybernetics and Informatics 2006*
- [12] S. P. Ugale, S. S. Morade, D. M. Chandwadkar "Implementation of DSP based five axis CNC machine control" *International Conference on Systemics, Cybernetics and Informatics 2006*
- [13] TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual.
- [14] Texas Instruments Manual on "Designing High-Performance and Power-Efficient Motor Control Systems" by Charlie Ice, C2000 MCU Marketing Manager.
- [15] F2837xD Workshop Workshop Guide and Lab Manual F2837xD-TTO by TI.
- [16] Code Composer User's Guide Literature Number: SPRU296 February 1999 by TI.
- [17] <http://www.ti.com/lit/ds/sprs439m/sprs439m.pdf>.
- [18] http://c2000.spectrumdigital.com/ezf28335/docs/ezdspf28335c_techref.pdf.
- [19] http://www.cs.bu.edu/_richwest/quest.html.