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An Efficient Algorithm for Memory Management of the DSP based CNC Machine using SD Card

Harshali J. Shendge[1], Prof. Dr. Sunil S. Morade[2]

PG Student [VLSI & Embedded System], Dept. of E&TC, K. K.W.I.E.E.R, Nashik, India[1]

Assistant Professor, Dept. of E&TC, K. K.W.I.E.E.R, Nashik, India[2]

ABSTRACT:The main objective of this paper is to implement file handling and file management system for CNC machine using the SD cardand hence the increase memory size to hold the large data of .CNC file. The system employ Dual core C28x DSP processor (TMS320F28379D) for file handling and file management system as well as performs various operations of CNC machine and it is mainly focus on the hardware structure and software program of File handling and file management system implement on the SD card. The SD card module is interface with Launchpad for the mass storage of data in the CNC machine. The Serial Graphical Display is interface with Launchpad F28379D along with the matrix keypad. The Texas instrument Code Composer Studio IDE environment is used to implement the algorithm for file handling and file management of the CNC machine. Another important task is to convert the .CNC file into the machine acceptable format for the tool processing in the CNC machine.

KEYWORDS:CNC, SD Card, Device driver, FAT32 File system, Launchpad F28379D, CCS, Controlsuite.

I.INTRODUCTION

Computer Numeric Control (CNC) is the automation of machine tools that are operated by precisely programmed commands encoded on a storage medium[1,2,3]. In modern CNC systems, end-to-end component design products are automated using DSP processor. The Texas instruments Delfino series DSP microcontrollers provide the cost efficient solutions in the manufacturing of the CNC machines. The C2000 Delfino MCUs LaunchPad development kit is an inexpensive evaluation platform for designers of high-performance digital control applications. This tool provides a great starting point for development of many high-end digital control applications such as industrial drives and automation, electric vehicles, and more. This LaunchPad development kit is based on the Delfino TMS320F28379D MCU which provides 800MIPS of total system performance between dual 200MHz C28x CPUs and dual 200MHz real-time-control co-processors (CLA). This powerful microcontroller contains 1MB of on-board flash and includes highly differentiated peripherals such as 16-bit/12-bit ADCs, comparators, 12-bit DACs, delta-sigma sinc filters, HRPWMs, eCAPs, eQEPs, CANs, and more. The LaunchPad development kit supports 12-bit ADC mode through the header pins and 16-bit mode can be driven with external differential signals.

The Dual core TMS320F28379D is a powerful 32-bit floating-point dual core microcontroller unit (MCU) designed for advanced closed-loop control applications such as industrial drives and servo motor control, transportation and power line communications. The dual real-time control subsystems are – bit based C28xfloating on-point CPUs, TI's 32 which provide 200 MHz of signal processing performance in each core. The C28x CPUs are further boosted by the new TMU accelerator, which enables fast execution of algorithms with trigonometric operations common in transforms and torque loop calculations; and the VCU accelerator, which reduces the time for complex math operations common in encoded applications[10,11]. This CNC machine requires a mass storage of data files which are further processed by the CNC machine. To support this FAT file management system we requires SD card to store the data files. This data is processed by the TMS320f28379D processor to execute the various operations such as turning, rolling, grinding, drilling etc. To transfer these files to SD card, SD card and USB module is interfaced with the TMS320f28379D Launchpad. It requires to develop a C Program to implement FAT file handling and management for the SD card. The

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SD card use SPI mode for communication with C28xMicrocontroller. The Launchpad is interfaced with GLCD and keypad for user interface with CNC machine. To perform multi axis operation of CNC machine, the microcontroller is further interface with stepper motor.

II. SYSTEM OVERVIEW

A. SD Card

Secure Digital (SD) is a flash memory card used in portable devices, including digital cameras and handheld computers. The F28379D microcontroller is communicating to the SD card through the SPI, the first step of the process is to configure the SPI of the device(fig1). The SPISTE(CS) of the F28379D is configured as a GPIO output and pulled high and low manually to meet timing specifications of the SD card. The software flow inside the SD card is shown in Fig2. The TMS320F28379D DSPs support an onboard SPI peripheral. This should be the preferred interface for applications using cards with smaller capacities, up to 2 GB. For higher capacity cards, you may want a higher data transfer speed and choose the SD mode[4,5]. The SD interface is implemented using general-purpose input/output (GPIO) pins to meet particular SD specifications. The interconnections for SPI modes are shown in Fig 1. The pullup resistors are specified as 10 K to 100 K for all the input signals (as opposed to a floating condition when card drivers are in high-impedance mode). CMD and DATA pins need to be pulled high. Though SPI mode does not use all DATA pins, the host must pull them high. The write protection (WP) pin is also pulled high. Filter capacitors are advised on each signal; however, the total load capacitance should not exceed 100 pF if seven cards are operating at a clock speed up to 20 MHz. A standard SD card can work with a supply voltage of 2.0 (min) to 3.6 (max) and draw up to 200 mA current; therefore, the F28379D devices VDDIO voltage rail of 3.3 V is used to power the card. Electro static discharge (ESD) protection can be added as additional precaution.

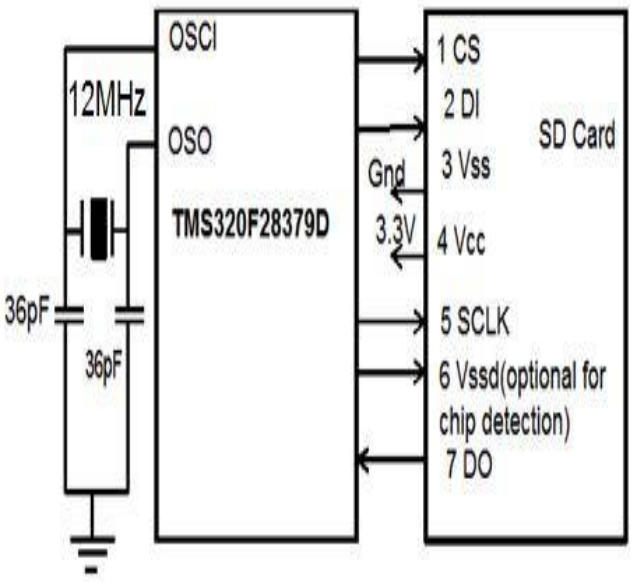
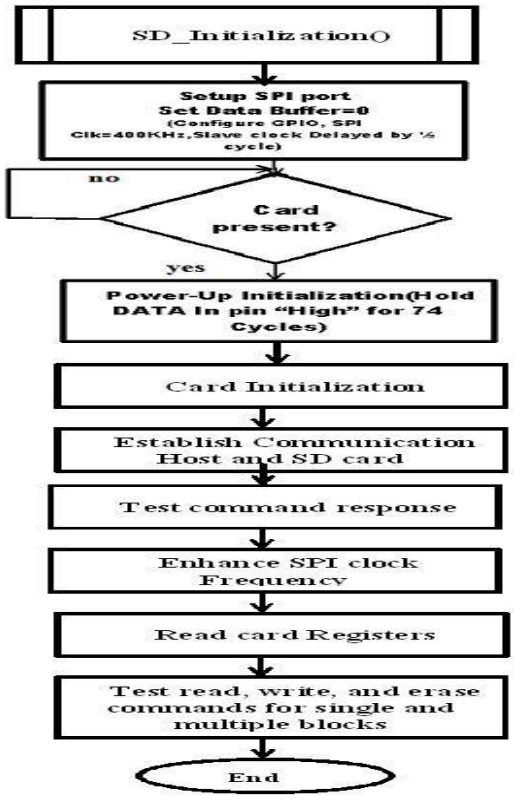


Fig1. Interconnections between TMS320F28379D and SD Card – SPI Mode



Fig(2): Software flow of the SD card

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B.Fat32 File System

The various file systems for the various devices are such as NTFS, FAT12, UDF, exFAT, FAT16, FAT32. The computer file system architecture is described by File Allocation Table (FAT). This File architecture system is supported by all the compatible devices such as personal computers and many mobile devices as well as various operating systems. From 1981, it is a well-suited format for data exchange between computers and devices of almost any type. The major three Fat File system are: FAT12, FAT16 and FAT32. FAT32 file systems are used for SD Card, USB flash Devices, Memory Cards and various portable embedded devices. The various file functions of Fat32 File system are as follows:

Fat32 File Function	Description
f_open	Open/Create a file
f_close	Close an open file
f_read	Read data
f_write	Write data
f_lseek	Move read/write pointer, Expand size
f_gets	Read a string
f_printf	Write a formatted string
f_eof	Test for end-of-file
f_opendir	Open a directory
f_closedir	Close an open directory

Table 1: Fat32 File Function

C. Hardware Design

The overall System block diagram is shown in below fig 3. The Launchpad development kit is based on the Delfino TMS320F28379D MCU which provides 800MIPS of total system performance between dual 200MHz C28x CPUs and dual 200MHz real-time-control co-processors (CLA). The SD card module is interface with the Launchpad for the mass storage of .NC files. These files are further used for deciding the course of actions of CNC machine in the tool processing. Also USB module can be interface with Launchpad along with Serial GLCD, matrix keypad and Steppermotor. The main objective is to implement file management system for CNC machine using the SD card and hence the increase memory size to hold the large data of .NC and .CNC file. The system employ Dual core C28x DSP processor (TMS320F28379D) for file handling and file management system as well as performs various operations of CNC machine and it is mainly focus on the hardware structure and software program of File handling and file management system implement on the SD card. The SD card module is interface with Launchpad for the mass storage of data in the CNC machine. The Serial Graphical Display is interface with Launchpad F28379D along with the matrix keypad. The Stepper motor interfacing with Launchpad f28379D is done for multi axis operation of CNC machine. The system uses Embedded C programming in the Code composer studio IDE environment. Another important task of the project is to convert the .CNC file into the machine acceptable format for the tool processing in the CNC machine. The project flow of the system is shown below in the fig 4. Here the system initialization first takes places and then the program files of the CNC machine (.CNC /.NC files) are copy and transferred to the SD card using USB pendrive. The Fat32 file system is implemented on the SD card using the design algorithm for file handling and file management of the CNC machine. The Serial GLCD, matrix keypad and Stepper motor is interface with the Launchpad.

The Graphical LCD is connected with Arduino UNO to generated serial GLCD is shown in fig 5. The Matrix keypad is interface to the Launchxl F28379D. The readymade C library for GLCD in arduinouno is available. The replica of Terminal window of the CCS is display on the GLCD using Serial communication. The Uart communication takes place between Launchpad and serial display. The serial display is obtained by connecting 128x64 GLCD with atmega328.The transmitter pin of the atmega328 is connected with the receiver pin of the Launchpad and similar receiver pin of the atmega328 is connected with the transmitter pin of the Launchpad. One important feature of the library is that it uses the Software Serial library to create an alternative serial port for the Arduino to communicate to the LCD

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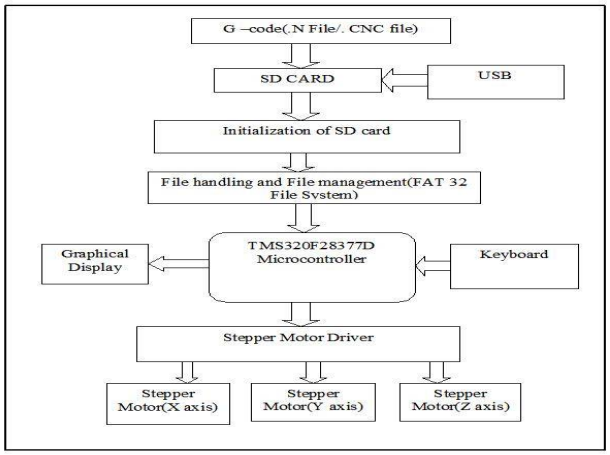

Fig 3: Block Diagram of Proposed System

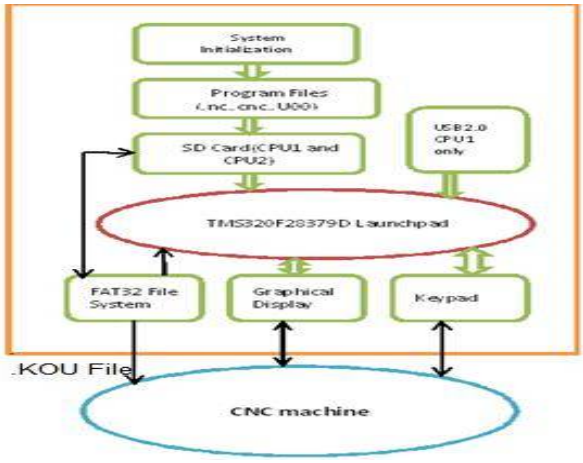

Fig 4: Project flow of system

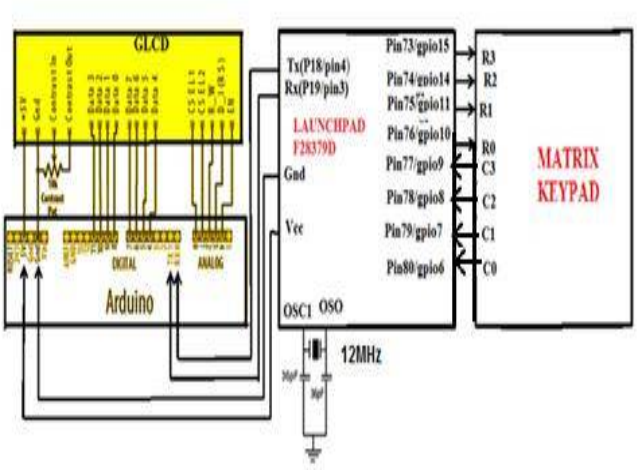

Fig 5: Interfacing GLCD and Matrix keypad with the Launchpad-F28379D

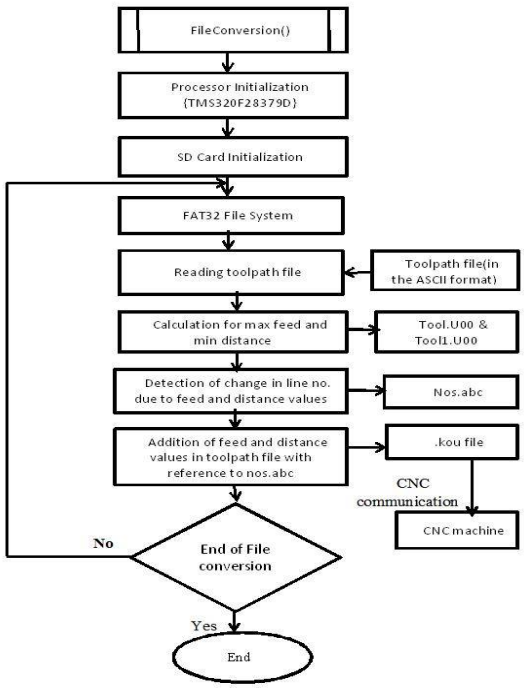

Fig 6: File conversion algorithm

D. Software Design

Here we are designing the device driver for the peripheral device SD card which is interface with Launchpad TMS320F28379D Microcontroller. The Text file in the Format of ASCII is selected from the SD card and then further processed according to the algorithm as follows:

1. Select .txt or .nc or .U00 file in the ASCII format.
2. For the tool processing, choose the acceleration time, maximum feed and maximum plunge for the tool processing
3. By calculating feed and acceleration rate create the tool.U00 and tool1.U00 files
4. To create nos.abc file which shows the line no. of G-code which are changed due to calculations.
5. To generate the .kou file with change in feed value and Emindistance for tool processing.

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This processing and coding is done by using C software Texas Instruments (TI) Code Composer Studio(CCS). 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 FAT32 file system is designed for SD card using dual core F28379D processor. Using FAT32 files from SD card can be read, write, copied or newly created according to algorithm as shown in fig. 6

III. EXPERIMENTAL RESULTS

The launchpad is interfaced with GLCD and Keypad for the user interactions. The replica of Terminal window of the CCS is display on the GLCD using Serial communication. The Uart communication takes place between Launchpad and serial display. The serial display is obtained by connecting 128x64 GLCD with atmega328.The transmitter pin of the atmega328 is connected with the receiver pin of the Launchpad and similar receiver pin of the atmega328 is connected with the transmitter pin of the Launchpad. The columns of keypad as c0,c1,c2,c3 are connected to the GPIO 6, GPIO7, GPIO8 and GPIO 9 respectively of Launchpad while rows r0,r1,r2,r3 are connected to GPIO10,GPIO11, GPIO14 and GPIO15 respectively is shown in fig 8.The Output results on the terminal window is obtained due to the various commands typed from keypad is shown in fig 7.

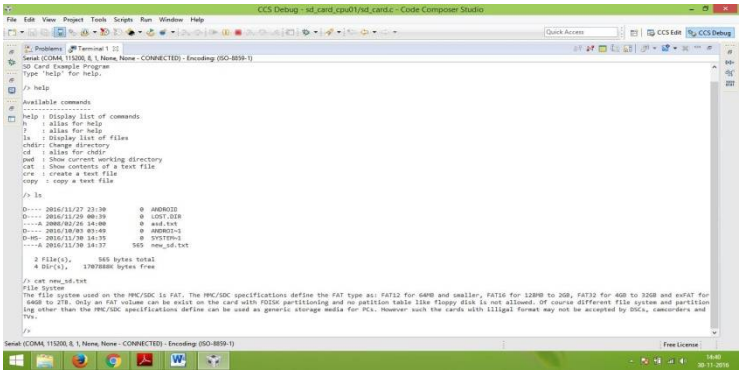

Fig 7: Output result on terminal window

Fig 8: Experimental Setup

IV.CONCLUSION

Thus it allows implementing the file handling and file management system of the DSP based CNC machine using SD card so that the memory space of the CNC machine is increased for the storage of the various files. These files are basically .CNC files which stores G and M codes in it. The G and M codes decides the operation procedure of the CNC machine and performed various tools related applications.This processor provides a cost effective solution for real time operation of the CNC machine with highest operating speed of 200MHz. The device driver for SD Card and Fat32 file management and handling system is implemented using Embedded C programming with the Code Composer Studio. Using FAT32 file management, the files from SD card is read, write, copied or newly created according to algorithm. The code efficiency is very high because code is optimized. The DSP processor takes the .U00 file from SD card, processed it for some mathematical calculations and generate .kou file. The .kou file is stored in the SD Card is given to the CNC machine with required feed and acceleration rate for tool processing operations from user. This processing and coding is done by using Embedded C programming with the Texas Instruments (TI) Code Composer Studio(CCS). The efficient algorithm for file conversion, Graphical display and matrix keypad is implemented using Launchpad F28379D. The CCS includes various 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 keypad and serial graphical display is interfaced with the Launchpad for the user interactions with CNC machines.

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