DSP in Embedded System

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Abstract

This paper describes a course on Digital Signal Processing microcontrollers, DSP microprocessors, DSP specific Field Programmable Gate Arrays, software development tools in embedded system design. This paper also describes a few embedded system applications where DSP plays a significant role.

Introduction

Digital Signal Processing theory, algorithm and applications have experienced a enormous growth in the last three decades. DSP microprocessors are used in many embedded systems from kitchen appliances to aircrafts. This paper describes a course on DSP in Embedded system design. This course emphasizes design of embedded systems using Digital Signal Processing microprocessors, and special DSP FPGA chips. Topics covered include, DSP microprocessor architecture, advanced instructions, addressing modes, interrupt, system design considerations, interfacing serial and parallel I/O, memory structure, arithmetic manipulations, software development tools, multiple DSP processor system design, and embedded system applications. Applications include automotive, multimedia, and wireless communications. Performance measurement, benchmarking and DSP system simulation, testing and debugging. Design of DSP embedded system using Synopsys COSSAP tools. The students will do a set of lab projects and a large embedded system design project.

A list of books and web references used in this course are given in the reference.
The course topics are listed below and the time spent on these topics.

1. Introduction to Embedded System hardware, software and selection consideration (2 hr)
2. Quick review of DSP theory: Sampling, aliasing, quantization, fixed point / floating point arithmetics, Convolution, FIR/IIR Filters, DFT, FFT, Z Transform (2hrs)

3. Review of Real time embedded system: real time OS, Buffering, Direct memory Access, Interrupts, I/O, multitasking, scheduling. (4hrs)
4. DSP microprocessors, Application Characteristics, Popular DSP processors – Texas Instruments, Motorola, and others (4hrs)
5. C5X- Fixed point DSP: Architecture, memory addressing modes, Arithmetic operations, Program Control.(4hrs)
6. C24X- motor control DSP (2 hrs)
7. C6X- Floating Point DSP : VLIW Architecture (2hrs)
8. C6X- Instruction set, Addressing mode, Assembler, ASM statement in C, Timers, interrupts, Multichannel Buffered Serial Ports (McBSP), DMA, memory considerations: Data Allocation, alignment, Pragma directives, memory models. (6hrs)
9. C6711 DSK Board and PCM3003 audio board description, programming example (2hrs)
10. Code development/ improvement: intrinsic, cross-paths, software pipelining; Code composer studio, Assembler/compiler/linker (4hrs)
11. FIR/IIR implementation on DSK (1 hr)
12. FFT implementation (1hr)
13. Adaptive Filters (1hr)
14. Noise Cancellation (1hr)
15. Matlab Support Tools, DFDP filter design package. (1hr)
16. Input/Output with the DSK- Stereo Codec (1hr)
17. C6711 based system design (2hrs)
18. Parallel processing with multiple DSP- C40 (2hrs)
19. Xilink DSP FPGA ((2hrs)
20. Fuzzy Logic and DSP (1hr)
21. Wavelet Transform and Huff Transform and applications. (2hrs)
22. Automotive and other Applications (5hrs)
    Electric Power Steering
    Engine Control and misfire detection
    Airbag control, Suspension control
    Antilock break, Collision avoidance
    Wireless communication

Presentation:

A number of papers were assigned for reading. Each student had to make one presentation on one of the topics during the term.

Lab type Assignments:

In the lab students develop programs in Assembly or C for DSP TMS320C6711 and test it using DSK in the lab. They also use the Code Composer Studio, Digital Filter Design package, Matlab DSP tool box, DSP FPGA. DSK C6711 was chosen for the lab since the hardware and software cost was nominal. The use of Code composer studio and C language relieves the stress of writing application programs in tedious assembly language.

Project:

Each student worked on a term project during the second half of the course. Details of the term project are made available in the course web.

Some of the projects done during the second half of the course are listed below. A brief description of these projects is given in the course web.

- Motor Controller using C24X for electric power steering
- Robot controller using C6711 DSK
- Thumb impression analyzer
- PID controller using C6711 DSK
- Speech Recognition.

Conclusion

We describe in this paper details of a lab oriented course on DSP in Embedded system. The course emphasizes both the real time aspects and DSP processor applications. This is a graduate level course. This course demands a lot of time and effort from the instructor and the students.

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Biography

DR. SUBRAMANIAM GANESAN, is a Professor in the department of Computer Science and Engineering, and Associate Director of Product Development and Manufacutring Center Oakland University, Rochester, MI 48309, USA He is working on automotive applications like: DSP based electric power steering, Fuzzy idle-speed control, road scene analysis for intelligent vehicles, real time lossless Image compression, mobile communication protocol, application of wavelet transform and Hough Transform . More details about him can be obtained from the web address: **www.secs.oakland.edu/~ganesan**

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