UPPSALA
UNIVERSITET

Project in Embedded Systems (15 hp)

Embedded signal processing

based on Atmel AVR microcontrollers

Group members: Anna (Project leader), Bertil, and Carl

Background

Real time digital signal processing (RT-DSP) is widely used in a huge variety of areas from industries to our daily life, ranging from MP3 players to cars and from airplanes to space shuttles. RT-DSP can be realized in different scales in terms of performance, speed and cost.

To have high processing performance and speed, one can use digital signal processors. A digital signal processor is a microprocessor specialized for real time digital signal processing. It has an architecture (e.g., a Modified Harvard Architecture) optimized for the operational needs of digital signal processing. Companies like Atmel, TI (Texas Instruments), Microchip, STMicroelectronics, Freescale, Analog Devices, NXP Semiconductors, etc., produce and provide DSPs with various speeds and performances. Modern DSPs can achieve a high clock speed of up to 1.5 GHz, and extremely high filter performance. The price and cost, however, are higher for higher processing performance.

Many RT-DSP applications do not need high performance and speed. In this case, one can use microcontrollers (MCUs). MCUs are another type of microprocessors that have different device type architecture (e.g., Harvard architecture) and peripherals. MCUs are traditionally used for control and interface applications where simplicity of design and R&D is more important than speed. Because of being low prices and costs for R&D, MCUs are more and more popular to use for real time signal processing with performance suited for specified applications.

This project is intended to implement real time signal processing based on Atmel AVR microcontrollers, aimed at low cost and low performance applications of digital signal processing.

Objectives

The objective is, based on Atmel AVR microcontrollers, to build signal processing units for various real-time signal processing applications which require low cost with sufficiently good performance. In particular, IIR and FIR digital filters, frequency analysis (based on FFT) and signal detection are to be implemented on the unit that may consist of analog-to-digital converters (ADCs), digital-to-analog converters (DACs), AVR UC3 microcontroller, communications ports and other I/O ports.

Preliminary tasks and work distribution

This project will be carried out based on Amtel AVR UC3 microcontroller. It is primarily divided into the following framework tasks:

- Analog and digital signal conversion with ADCs and DACs
- Implementation of IIR and FIR digital filters
- Development of algorithms for frequency analysis (based on FFT) and signal detection

The C and C++ will be used for programming.

The project will be done cooperatively with the distribution of work among the group as follows

- Anna is mainly responsible for analog and digital signal conversion and frequency analysis
- Bertil is mainly responsible for signal detection
- Carl is mainly responsible for the implementation of IIR and FIR digital filters

Suggestion of grading criteria and the grade to be achieved

{add the grading criteria you suggest and the grade, 3, 4, or 5, you wish to achieve here}

A. Suggestion of grading criteria

Grade 3: Theories on signal sampling, digital filters, signal analysis in time and frequency domains, and signal detection have been studied comprehensively; ADCs and DACs, and 1st - 4th order FIR and 1st-2nd order IIR digital filters of low pass (LP) and high pass (HP) are implemented successfully; FFT is Implemented and single peak in the signal spectrum can be detected; *[tasks finished at basic level; and they are measurable and visible}*

Grade 4: Digital filters of LP and HP can be designed; Up to 128th order FIR and 8th IIR digital filters of low pass and high pass are implemented successfully; Algorithms for signal frequency analysis based on FFT are developed that can be used to detect multiple peaks, e.g., two spectral peaks of dual-tone multi-frequency signals; *[tasks finished at advanced leve }*

Grade 5: Any types of FIR and IIR digital filters, i.e., LP, HP, band pass and band stop, can be designed and their implementations are successful; Algorithms for signal frequency analysis based on FFT are developed that can be used to extract features related to real world applications, e.g., extract Doppler shift from signals reflected from a moving object; Signal detection algorithm based on correlation is implemented successfully *[tasks finished at challenging level}*

B. The grade to be achieved: 5 (4 or 3)

Preliminary time schedule

Week	***Work content***
1	work out preliminary approaches to the project
2	acquire basic knowledge and hands-on skills on Atmel AVR UC3 microcontrollers and development tools like AVR Studio 6 and debugger (e.g., AVR Dragon and JTAGICE mkII); and study literature and documents on Atmel AVR Software Framework (ASF) and DSP
3	work on ADCs and DACs to
4 – 6	develop algorithms for digital filters and frequency analysis and signal detection
7	start to write a report and continue developing the algorithms
8	focus on writing a report