TDT4258 Assignment 2 Group 1

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1 Abstract

For this assignment we wrote a program producing distinct sounds when buttons on the microcontroller where pressed. The program was witten in C without a Operation System. We used the internal DAC to make audible audio waves.

A high-level programing language like C gives you a nice abstraction from the hardware while still maintaining direct control. Compared to assembly it is much simpler to create abstract datatype and dealing with variables instead of registers.

Programming without an Operation System gives us full control over the hardware, but it does not provide any abstractions, like device drivers. This requires us to implement a partial driver for all the devices we want to use. In this assignment we use LEDs, buttons and DAC.

Contents

2 Introduction

The second assignment introduces us to a new hardware device, the ABDAC. We also utilize the the buttons and LEDs used in assignment one. This gives an introduction to programming with audio devices and how to produce audio digitally.

To the development environment from assignment one we add the GCC C-compiler.

The gist of this assignment is to produce different sounds when the buttons on the board are pressed. The program should be implemented in the C programming language without the support of a Operation System. We implemented two modes. The first mode is a 7-note piano. The second is a playback function which plays a different predefined sample for each button. The button SW0 is used to toggle between the modes.

In order to make the program energy efficient the CPU is set to sleep and the DAC is shut down when a tone is not playing.

3 Overview of the Solution

3.1 States

3.1.1 Modes

The program has two main modes. These are Piano and Playback. To switch between state the **SW0** is pressed.

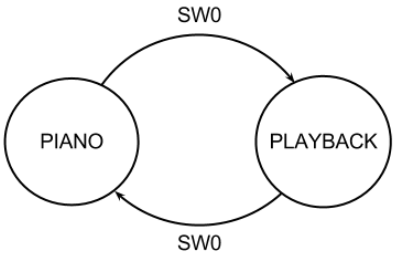


Figure 1: State diagram for modes

3.2 Datastructures

In order to play sounds the sound samples has to be saved. A sample contains four tracks where each track is a series of notes in a linked list.

3.2.1 Note structure

A musical note is represented in the program by the datatype note_t defined in **note.h**.

note_t
int pitch
int duration
int progress
double cutoff
note_t *next

Figure 2: Datatype for notes

This type is used as a linked list to produce a track. The pitch is a number which relates to the frequency of the note. Pitches are defined in **tone.h** (C, D, .., C2, C3, ...). The duration is how long the note lasts, durations are also defined in **tone.h** (WHOLE, HALF, FORTH, etc.). The pogress field is a state variable used when the tone is played in order to know when its done, its always set to 0. The cutoff is to let different tones have different quality. The range of

the cutoff is 0.0 - 1.0 where 0.5 is a very *staccato*[1] tone and 1.0 is *glissando*[2]. The value 0.875 is used for ordinary notes.

3.2.2 Sound Tracks

The **playback.c** file contains a array, *tracks*, of constant size 4. This array has pointers to the current point of each track. A track is a linked list of notes. The list is NULL terminated. As there are 4 tracks, a sound sample can play four tones at a time.

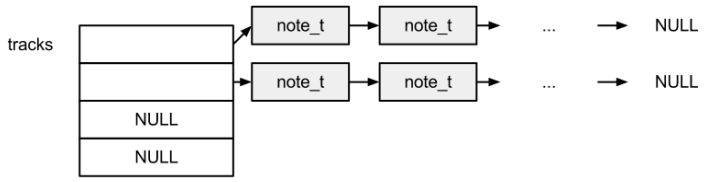


Figure 3: Illustration of tracks setup with 2 tracks

3.2.3 Sound Samples

The 7 different soundsamples are contained within a array of function pointers inside the interrupt.c file. Each function initilizes the tracks array by using the **set_track** function.

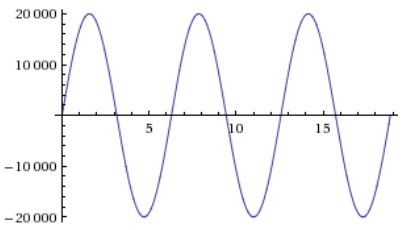
3.2.4 Sine Table

As the abdac interrupt routine is on a deadline, it has to conserve it's computing. Computing a **sin** function on every interrupt is wastefull and to timeconsuming. To make this a constant operation at runtime a sine table is computed on startup and stored in the **sine_table** in the **samples.c** file.

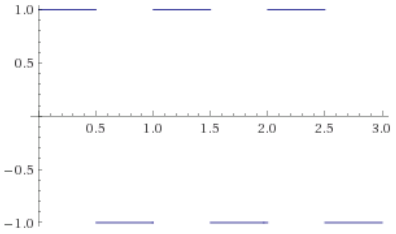
3.3 Waves

To make sound waves we need some functions producing wave signals. The following waves are implemented in **samples.c**.

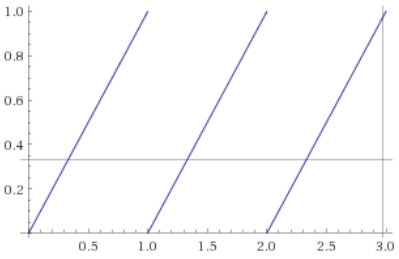
[1] A shortened duration of the tone
[2] When tones glides into each other



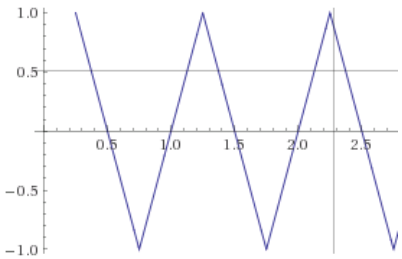
(a) Sine wave



(b) Square wave



(c) Sawtooth wave



(d) Triangle wave