Automatic Piano Tuner
Group 49
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The Problem
The Problem

Problem

Pianos require periodic tuning to function
- Specialized skills & tools
- High cost, $200
- Time consuming

Solution

A device which can automatically detect frequencies and tune piano
- Low skill requirement
- Cost equal to a single tuning session
- Expedited processes
Design
Design – Block Diagram

Automatic Piano Tuner – Block Diagram

Controller/Processor
- Microphone
- Amplifier
- Audio Acquisition
- Microcontroller
- Memory

Control System
- 5 V

Motor Assembly
- Motor Controller
- DC Motor
- Electric Motor Drive

Power Management
- Battery Pack
- Battery Subsystem
- Voltage Regulator
- Power Regulation

User Interface
- Push Buttons
- On/Off
- Buttons
- LCD Display Module
- Display

Legend
- Analog Signal
- Digital Signal
- Battery
- 5 volt
- 12 volt
Design - PCB

- Power Management
- Motor Control
- Display
- Controller
- Programming
- Microphone
Specifications

- 9 – 14 Nm Torque
- 4 A Current
- Motor Controller

Buttons to set desired frequency
  • Save frequencies values in memory to save RAM space

Compare frequency from microphone to desired frequency
  • Use rolling average to smooth values

Move motor depending on difference in frequencies
  • Greater frequency difference allowance on tightening

Autocorrelation

- First implementation of frequency detection algorithm
- Compares lagged signal against original signal to determine period
- Good noise rejection, fast through FFT speed

Period Estimation

- Compares two ADC samples to detect positive slope during zero-crossing
- Measures the time passage between positive zero crossings using ADC sample rate to estimate period
Design – User Interface

Note Select

- Up Key
- Up Octave
- Down Key

Trigger

Note Select

Power

LCD Screen
Test Results
Test Results - Audio Acquisition and Control

- Frequency range 27.5 Hz - 4186 Hz
- Differentiate between frequencies 1.6 Hz apart
- Determine frequency in less than 5 sec
Test Results - Power Regulation, Battery

Power Regulation

- Provide 12V to the ‘Motor Assembly’
- Provide 5V to majority subsystems

Battery System

- Rechargeable
- Remain powered for 2 hours at load
Able to rotate piano tuning pin

Able to produce the required 9-14 Nm
  • Provides at least 9.83Nm of torque

\[ l = 10cm, f = 22.1lbs \]

\[ \text{Torque} = \text{force} \times \text{length} = (22.1lbs) \times \frac{4.448N}{1lbs} \times 0.01m \]
Test Results - Buttons and Display

Display
- Display current note and octave
- Update display after button press < 1sec

Buttons
- Pressing note select buttons updates desired frequency < 1sec
- Disable dual up/down button press
Challenges
• Shortage of components, especially microcontrollers limited us to purchasing an Arduino Mega and desoldering

• Migrated chip from Arduino board to PCB, would not program with the standard ICSP header

• Zero information online indicating the source of the problem
  • AVR uses internal oscillator, Arduino reprograms to use external oscillator
  • Used a signal generator to simulate oscillator and burn new bootloader
Challenge – Display

- LCD display VO pin required voltage divider
- LCD display LEDA pin required smaller resistor
- Using MegaCore AVR pinouts
Challenge – Frequency Detection

- Project was designed around frequency detection scheme using autocorrelation. Worked independently on computer.
- KISS FFT library uses large data structures for storing real and imaginary information.
- Arduino has no clear way of indicating what error is occurring.

```cpp
for(int i = 0; i < FRAME; i++){
    output[i] = fft_real[i];
    Serial.println(i);
}
```

Memory Overflow

```plaintext
#######Serial Monitor #######
% 0
% 1
% 45684294
```
Take Away
Conclusion – What We Learned

• Technical Skills – Soldering, PCB fabrication, full system design

• Engineering team project experience

• Professional presentations of results
Further Work
Further Work

Project can be further enhanced by improvements to

**Useability**
- Smaller box
- Arm to hold device by

**Frequency Detection Accuracy**
- Better microphone
- Autocorrelation frequency detection
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