Automatic Guitar Tuner

Project Proposal

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1.0 Introduction
1.1 Statement of Purpose

Any experienced musician knows that tuning an instrument by hand is always a huge burden. The tuning procedure involves constantly plucking a string, turning a peg, and then repeating this process until the string is in tune. In addition, tuning by hand can cause inaccuracies in the instrument's tuning. For our project, we would like to solve these problems by creating a device that listens to a plucked string and then automatically turns a tuning peg using a motor until a string is in tune. The user will only have to pluck the string once and the device will ideally be more accurate than a person's hand. This will significantly decrease the time it takes for a musician to tune an instrument and increase the tuning accuracy.

1.2 Objectives
1.2.1 Goals

-Give a user the ability to tune an instrument with minimal input
-Give the user a way to tune an instrument more accurately
-Allow the device to be small, portable, cheap, and easy to use

1.2.2 Functions

-Tunes a guitar without the need of a user turning the peg
-Determines the frequency of a string by the use of an audio processing circuit and presents the frequency to the user
-Automatically turns the tuning peg until a string is in tune

1.2.3 Benefits

-Allows the user to tune a string by selecting a frequency and plucking a string, decreasing the time and effort it takes to tune
-Tunes more accurately than a human
-More affordable than current designs

1.2.4 Features

-User interface for showing whether string is sharp, flat or in tune
-Useable with all guitars and most string instruments
-Manual control of motor to wind/ unwind strings when changing strings

2.0 Design

2.1 Block Diagrams

Each design block will be implemented in a modular manner to ensure independent functionality. Verification of each individual design block will be completed before testing at the system level. Figure 1 shows a top-level system layout, with each arrow indicating the direction of the signals moving throughout the device.

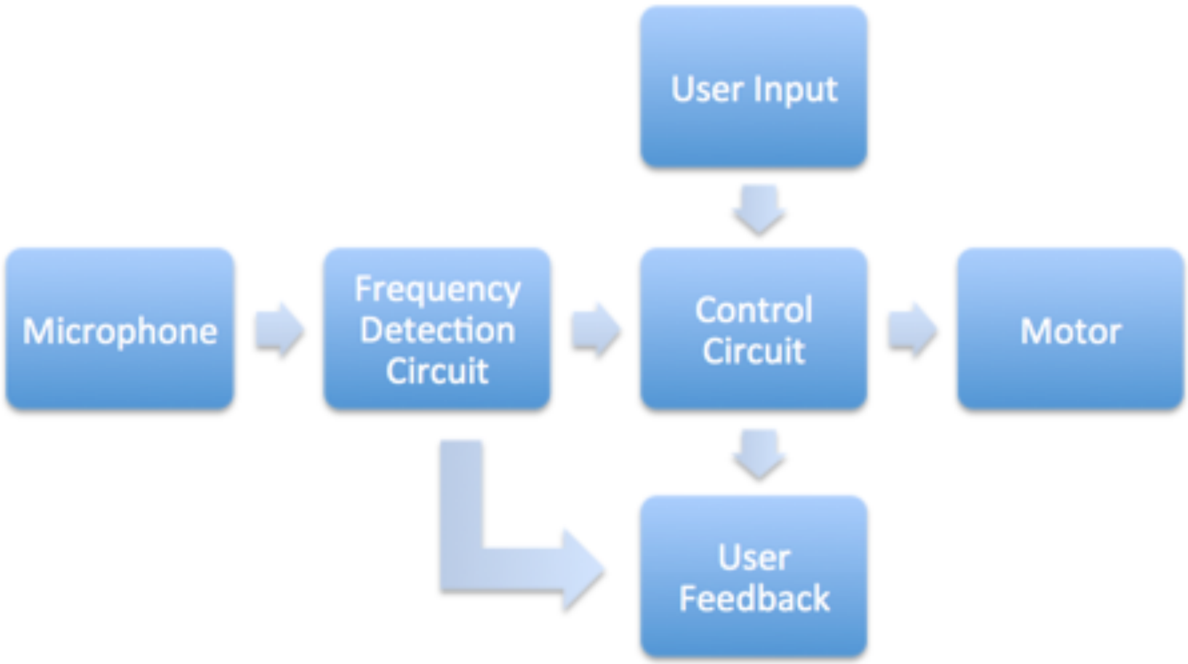

Figure 1: High Level System Layout

2.2 Block Descriptions

Microphone:

The microphone will be small and discrete. It will be similar to the ones used in cellular devices. This device will take in the sound from the plucked guitar string and pass the signal on to the frequency detection circuit.

Frequency Detection Circuit:

This circuit will determine the most significant frequency component of the input signal from the microphone, and convert it to a corresponding DC voltage. This DC voltage will then be passed on to the control circuit and the user feedback design block.

User Input:

This will consist of 6 buttons, allowing the user to select the note they are tuning, and the system will tune to the selected output frequency. The selected value will be passed on to the control circuit.

User Feedback:

This design block will consist of an array of LED's which will indicate the current sharpness/flatness of the string being tuned by lighting the LED in the position corresponding to the position the note lies on the sharp to flat spectrum. Additionally, the currently played note fill display its' corresponding frequency on a 4 digit hex display.

Control Circuit:

This design block will be responsible for controlling the tuning peg motor's direction and speed to properly tune each note. This circuit will receive a DC input signal from both the user and the frequency detection circuit. It will then compare the two input signal values and pass a resulting signal to the tuning peg motor. Utilize H-Bridge for bidirectional control of DC motor.

Motor:

This design block will be responsible for physically turning the guitar's tuning peg. It will receive signals from the control design block to designate the direction and speed with which it will turn the tuning peg. The motor will be an electric servo operating on 3 to 5V DC.

2.3 Block Requirements

Microphone:

Needs to simply represent the input signal as a voltage waveform. Output goes to the Frequency detection circuit.

Frequency Detection Circuit:

The Frequency detection circuit will need to measure the fundamental frequency of an analog voltage waveform from approximately 30 Hz to 1000 Hz. It will need to output the frequency represented as 8 bits. This string of bits will then be sent into the control circuit.

User Input:

This unit will allow the user to choose a frequency to tune a given string to. The user will enter the desired note using an array of buttons (one for each note). A simple circuit will convert the values from the user interface into a frequency represented by 8 bits. This output will be sent into the control circuit.

Control Circuit:

The control circuit will have the 8-bit measured frequency (from the frequency detection circuit) and the user's tuning frequency as inputs. It will need to send either a forward or reverse signal to turn the motor, and a stop signal when the motor needs to be stopped. It will determine which output to send depending on the relationship between the two frequency inputs.

User Feedback:

The user feedback unit will be a hex display and a few LEDs that show the measured frequency and whether it is sharp or flat relative to the tuning frequency. The input to this unit will be the output of the control circuit and the 8-bit measured frequency from the frequency detection unit.

Motor:

This motor will be capable of at least 2.5 in-lbs. torque to ensure it can tune all strings to their desired frequency. The end of the motor shaft will have an adjustable tuning peg adapter. The motor will need an internal gear set to achieve rotational frequencies as low as 0.5Hz. This motor should have a slip clutch built-in to function as a torque limiting device to prevent over-torqueing leading to broken strings which is a safety hazard. The shaft will have guarding and run at a rotational frequency of about 0.5Hz, reducing the risk of the user being harmed by the turning motor.

Power Supply:

The power supply will be responsible for powering all components of the system. It will consist of a battery pack, which wires AA batteries in series to achieve 5 V DC. Our system will be self-contained, eliminating the risk for the user to interact with any electrical components and therefore mediating electrical shock risks.

3.0 VERIFICATION

3.1 Test Procedures

Microphone

This unit will be tested by observing the output of the microphone on an oscilloscope after a guitar string is strummed, and making sure that the fundamental frequency of the observed waveform matches the frequency of the note played.

Frequency Detection Circuit:

Testing of this unit will be conducted by connecting a function generator to the input of the unit, and making sure the 8-bit output of the circuit corresponds to the frequency from the function generator.

User Input

Testing of this unit will be conducted by checking that the 8-bit output corresponds to the user's input frequency.

Control Circuit:

Testing of this unit will be conducted by supplying 8-bit strings of values representing the measured and selected frequencies. The output will then be tested to see if it gives the correct motor signal. In addition, the values of the inputs will need to be manually changed to simulate the strings being tightened or loosened by the motors until two frequencies match, which is the point where a stop signal needs to be given by the output.

User Feedback:

Testing of this unit will be conducted by entering an 8-bit input and checking the hex display of the user feedback interface to ensure the displayed frequency corresponds to the input value. Testing of the LEDs will be conducted by sending 4-bit inputs corresponding to a sharp or flat note, and making sure that the correct LEDs light up.

Motor:

The motor can be measured by sending DC values to the terminals of the motor and making sure it spins. The motor needs to change spinning direction when the polarity of the DC input changes and needs to stop when the input goes below a certain threshold. The motor’s torque will be tested on the tuning pegs of the guitar used for this project.

3.2 Tolerance Analysis

The tolerance analysis will be based on the output of the control unit based on input frequencies. The signal needs to output a “stop” whenever the measured frequency is within 2 hertz of the tuning frequency, or if the input signal is below a certain threshold. Otherwise, the output needs to be a rotate signal. This will be tested by sending signals from a function generator into the frequency detection circuit while holding values constant at the tuning frequency input.

4.0 COST

4.1 Labor

Name	Hourly Wage ($/hr)	Total Time Invested	Total = 2.5x Total Time Invested x Hourly Wage
Dariusz Prokopczak	$35.00	150 hrs.	$13,125.00
Stephan Erickson	$35.00	150 hrs.	$13,125.00
Total		300 hrs.	$26,250.00

4.2 Parts

Component	Quantity	Unit Cost	Total Cost = Quantity x Unit Cost
LEDs	8	$0.10	$0.80
Motor	1	$20.00	$25.00
Microphone	1	$3.00	$3.00
TTL Chips	15		$20.00
Capacitors, Inductors, Resistors			$25.00
Buttons	6	$3.00	$18.00
Hex Display	1	$3.00	$3.00
Switches	2	$4.50	$9.00
Batteries/ Power supply	1	$5.00	$5.00
H-Bridge Chip	1	$2.30	$2.30
PCBs	2	$35.00	$70.00
Total:			**$181.10**

4.3 Total Cost

Labor	$26,250.00
Parts	$181.10
Total Cost	$26,431.10

5.0 Schedule
5.1 Detailed Schedule Breakdown

Week	Task	Responsibility
9/15	Finalize & hand in proposal	Dariusz
9/15	Design Preliminary Motor Control Circuit & User Interface	Stephan
9/22	Design Preliminary Frequency Detection Circuit & test basics on proto-board	Dariusz
9/22	Finalize design review & order first set of parts	Stephan
9/29	Meet with Mech. Shop for mounting & tuning peg adaptors design considerations, Design Review	Stephan
9/29	Test basic parameters (ie. voltage from microphone, guitar note waveform), Design Review	Dariusz
10/6	Start circuit testing & simulation with ordered parts on proto-board/ lab equipment & record results	Dariusz
10/6	Begin motor control testing & record results	Stephan
10/13	Debugging/Generate PCB schematics	Dariusz
10/13	Order PCB & Test User Interface	Stephan
10/20	Design device enclosure & request parts from mech shop/debugging	Dariusz
10/20	Begin to assemble system, linking design modules, & test	Stephan
10/27	Assemble PCB for frequency detection	Dariusz
10/27	Modify/ Update PCB schematic for 2nd Iteration (if needed)	Stephan
11/3	Tolerance Analysis	Dariusz
11/3	Verification of Specifications	Stephan
11/10	Fix Remaining Issues, Mock Demo	Dariusz
11/10	Prepare Final Paper, Mock Demo	Stephan
11/17	Prepare Final Demo	Dariusz
11/17	Prepare Final Presentation	Stephan
11/24	Thanksgiving Break	
12/1	Demo	Dariusz & Stephan
12/8	Final Presentation, Hand in Final Paper, Check in Supplies	Dariusz & Stephan