Perfect Pitch Instruments
School of Engineering Science
Burnaby, BC · V5A 1S6

ensc340-pp@sfu.ca

September 25, 2000

Dr. Andrew Rawicz
School of Engineering Science
Burnaby, British Columbia
V5A 1S6

Re: ENSC 340 Project Proposal for an Automatic Guitar Tuner

Dear Dr. Rawicz:

The attached document, Proposal for an Automatic Guitar Tuner, outlines our project for ENSC 340 (Transducers and Embedded Systems). Our goal is to design and develop an automatic guitar tuner that will quickly tune a guitar with one single strum.

The purpose of this proposal is to provide an overview of our product, outlining design considerations, resources, budgetary information and sources of funding. A brief comparison between similar products in the marketplace and the advantages of our product over them is also included, along with a project schedule complete with milestones.

Perfect Pitch Instruments was established by five sharp, creative and talented engineering science students including Gina Millar, Maria Trinh, Aaron Schellenberg, Terrence Yu and Reva Vaze. Should you have any questions or concerns regarding our proposal, please feel free to contact me at (604) 584-8926 or via email.

Sincerely,

Maria Trinh
CEO
Perfect Pitch Instruments

Enclosure: *Proposal for an Automatic Guitar Tuner*

Perfect Pitch Instruments

Proposal for an
Automatic Guitar Tuner

Project team: Gina Millar
Aaron Schellenberg
Maria Trinh
Reva Vaze
Terrence Yu

Contact personnel Maria Trinh
ttrinha@sfu.ca

Submitted to: Dr. Andrew Rawicz
Steve Whitmore
School of Engineering Science
Simon Fraser University

Date: September 25, 2000

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Executive Summary

Picking up a guitar for the first time is an exciting and challenging experience. A new student has many hurdles to surmount in learning how to play effectively: developing hand dexterity, developing calluses at the fingertips, developing a sense of rhythm and co-ordination, and perhaps the most difficult of all, developing a sense of pitch.

"Perfect pitch" is the ability to identify a note on the musical scale without having any reference note for comparison. Only a small proportion of human kind has this natural ability, but it is widely known that a person's sense of pitch can be bettered with practice.

Many students become discouraged or are turned away from learning how to play the guitar at the early stages, when they realize that they cannot grasp a sense of pitch right away. Electronic tuners and pitch pipes exist to help guitar tuning, but they are a hassle, and are sometimes an embarrassment to use when performing in front of others. A guitar player can have an automatic tuning device installed into their existing guitar, but often for a price that is greater than the guitar itself.

This document proposes developing a device that would be installed in a guitar at the time of manufacture. This accessory will be capable of tuning a guitar with one simple strum, and would be suitable for all skill levels ranging from beginner to professional. The tuner can help to ease the learning curve for a novice guitarist or provide a performer on stage with a quick and effective means for tuning their guitar between songs to whatever settings they desire. Better yet, the price of a guitar with this device installed would only cost a fraction more than a guitar without the tuning mechanism.

Perfect Pitch Instruments is comprised of three third year and two fourth year engineering students. We all have varying expertise in analog/digital circuit design, and a wide range of software design, from real time operating systems to microprocessor assembly language programming.

We propose the engineering cycle for this project will encompass research, design, and construction. This cycle will span a 13-week period. December 1, 2000 is the scheduled completion date for an operational prototype. The entire project is tentatively budgeted at $800.00, which we will partially fund ourselves, and expect to obtain the rest from a variety of sources.

Introduction

“Perfect pitch” is the ability to identify a note on the musical scale without having any reference note for comparison. Although the scientific and psychological aspects of perfect pitch are not well known, one thing is certain: whether perfect pitch is an inborn talent or an acquired trait, it need not be an essential or prerequisite for a musician.

The goal of our project is to design and develop an automatic electric guitar tuner that would eliminate the hassle involved with tuning a guitar manually. Although tuners exist in the marketplace today, many are handheld requiring the user to pluck a string with one hand, hold the tuner with another hand, and adjust the tension in the strings with another. Clearly too many hands are needed, and the tuning process is unnecessarily time consuming. The few existing automatic guitar tuners cost thousands of dollars, and prove unaffordable for the general public.

We envision an automatic guitar tuner that would be installed in a guitar at the time of manufacture. This accessory will be capable of tuning a guitar with one simple strum, and would be suitable for all skill levels ranging from beginner to professional. The tuner can help to ease the learning curve for a novice guitarist or provide a performer on stage with a quick and effective means for tuning their guitar between songs to whatever settings they desire.

This document is a proposal providing an overview of our product, outlining design considerations, resources, budgetary information and sources of funding. A project schedule complete with milestones is also included, along with a brief introduction to the project team.

Possible Design Solutions

The pitch that a certain guitar string can produce is dependent on three things – its length, its thickness, and its tension. All the open strings on a standard six-string guitar are the same length, but each one is of a different thickness or gauge. The thickest string gives the lowest notes and the thinnest string gives the highest. By adjusting the tension of each of the strings, one can control exactly what the pitch of the note will be when the string is struck. Tightening a string will raise the pitch of the note, and loosening it will lower the pitch. Over the years, guitarists have relied on a few techniques to try to keep their instruments in tune.

1. Pitch Pipes

Specifically designed for tuning a guitar, pitch pipes produce six different notes, each corresponding to one of the six open strings. Using these notes as a reference, the user turns the tuning heads to either increase or decrease the tension of the strings until the note that the string produces matches that of the pitch pipes. Since the process of comparing the pitch of the different notes is left up to the user, the accuracy of the tuning is dependent on the individual's ears. The problems with pitch pipes can also be extended to any of the other tuning methods that involve giving a reference tone, including tuning forks.

2. Electronic Tuners

A fairly recent introduction in terms of the guitar, electronic tuners take the sound from the guitar, either through a microphone or directly through a guitar's pick-ups, and tells the user if their instrument is in tune or not. Displays vary from meter needle, to liquid crystal displays, or to stroboscopes. These readouts can be confusing at times, as they do not always readily show how the user should tune their instrument. Although electronic tuners take the human factor out of the tuning equation, the user still has to manually turn the tuning heads for adjustments.

3. Existing Automatic Guitar Tuners

With recent advances in electronic components and equipment, it was only a matter of time before the art of tuning the guitar was as easy as pushing a button. Certain companies offer to retrofit guitars so that its strings never go out of tune. This can be a problem if you own a vintage - and therefore expensive - guitar that you do not want to be altered. Also, the cost of some of these retrofits can be upwards of two thousand dollars, certainly too high for the beginner guitarist.

Proposed Design Solution

Our proposed design solution is a guitar that wholly automates the tuning process. That is, the comparison of different notes is done electronically, and the adjustment of string tension is done electro-mechanically.

The Process Overview is diagrammed in Figure 1. Essentially, the user all but has to strum the strings on the guitar and the rest is done automatically. The sounding audio frequencies are conditioned and processed electronically, and are subsequently provided as inputs to a control module. After comparing the pitch of the strings to their desired pitch, the control module adjusts the tension in the strings electro-mechanically, by way of motors, gears, solenoids, etc. The entire process is implemented in a feedback loop, so that the input to the actuators is adjusted dynamically while tracking the pitch of the string. The process completes once the strings are tuned to their desired frequencies. Then it is time to rock!

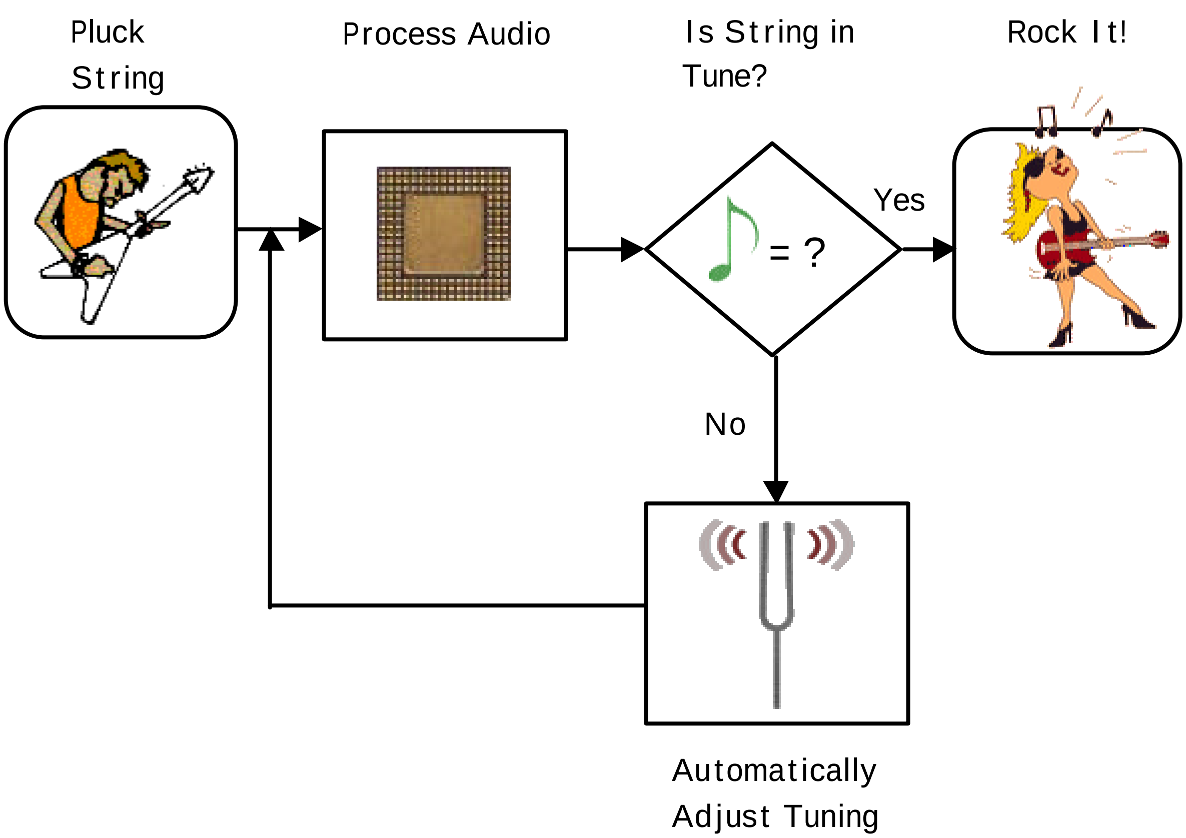

Figure 1: System Block Diagram

Since our design is incorporated discretely inside the body of the guitar, there is no need for the user to carry peripheral devices such as electronic tuners. A guitar that is always in tune will have improved playability, and will make learning much easier. Experienced guitarists will also benefit from the automatic guitar tuner's ability to change from one tuning to another in seconds, letting the user spend less time tuning their instrument and more time playing it.

Although a few automatic guitar tuners are already out on the market, they are still not in common use because of their high cost and their focus directed at expert guitarists. Our design will give guitarists a low cost, hassle-free, and accurate means to keep their instruments in tune.

To measure the performance of our device we will use electronic tuners readily available on the market to ensure that the guitar has been tuned to the desired pitch. Also, we will use readouts from an oscilloscope to measure the exact frequency of the output of the guitar.

Constraints on the scope of our project include time, funding, and physical properties of the automatic guitar tuner components. We plan to have a working prototype of our project by the end of the allotted thirteen weeks. This consists of a guitar that will be able to tune itself without any human interaction save for strumming the strings.

Sources of Information

To help us in the development process, we are planning on exploring various sources of information. The engineering lab staff at Simon Fraser University will be a great asset to us while component sourcing as they are familiar with the numerous mechanical and electronic components available. In addition, we may talk to past project groups that used similar parts as the ones we need to find out which ones they preferred.

For the electrical and mechanical design, we may refer to books, articles, journals, and the internet to provide us with knowledge that we have not gained already through course work. We may also approach professors during different stages to offer their insight into areas of their specialty (i.e. signal processing, circuit design, machining, etc.).

We will also consult our past co-op employers for design advice, equipment, and for advice on funding and support.

Mike Volker's website, www.sfu.ca/~mvolker is a good source for issues concerning business and money matters. We have already used some of the information provided on this website for determining funding resources.

Budget

Table 1 outlines a tentative budget for our automatic guitar tuner. Most expenses have been overestimated by at least 15%, and a contingency expense of $100 has been added for safer budgeting.

The actuating components include all the motors and sensors that the automatic guitar tuner may require during prototype development. The mechanical components include the gears, rotating shafts, and other nuts and bolts required to complete the actuating mechanism. The electronic components include the microprocessor, the operational amplifiers, logic gates, resistors, capacitors, inductors and other electronics required to complete the circuitry of the automatic tuner. Depending on the type of microprocessor we choose, the software development system may come without fee.

Table 1: Tentative Budget

Expense	Estimated Cost
Second-hand Electric Guitar	$100
Actuating Components	$300
Mechanical Components	$100
Electronics	$100
Software development system	$50
Power Source	$50
Contingency	$100
Total	**$800**

Funding

Each one of our group members is willing to contribute a cash amount equivalent to the price of an average textbook for this course (around $125 each), which comes to a total of $625 from the five of us. For the remaining $175, we will look to several other sources of funding.

We are currently in the process of applying for the Engineering Science Student Endowment Fund for a small amount in funding. In addition, we plan to call The Information Science and Technology Agency, which offers a Technology Assistance Program that can cover up to 50% of research and development costs for small start up firms like ours, up to $40,000 per company. Our past co-op employers are angel investors and avid supporters of music projects like ours. They may agree to contribute a certain amount of funding or equipment to our cause. In addition, we plan to contact local low-end guitar manufacturers who build guitars for students (Yamaha, Samick, etc) for donations, perhaps even an electric guitar. Our local MLA's (Burnaby, Surrey, North Delta and Richmond) will be contacted about this technological project and may also agree to contribute a small donation as well. The APEG Opportunity Fund supports special projects around BC, so we will definitely put in our bid for funding.

We also plan on entering our project in several engineering competitions in the future, such as the Western Engineering Conference and Competition that is to be held in February 2000, in hopes of reimbursing our team members with awards and prize money.

Schedule

Figure 2 shows the Gantt chart of our expected time spent on the various tasks involved with our project. Figure 3 shows the corresponding expected completion dates for the various tasks mentioned in Figure 2.

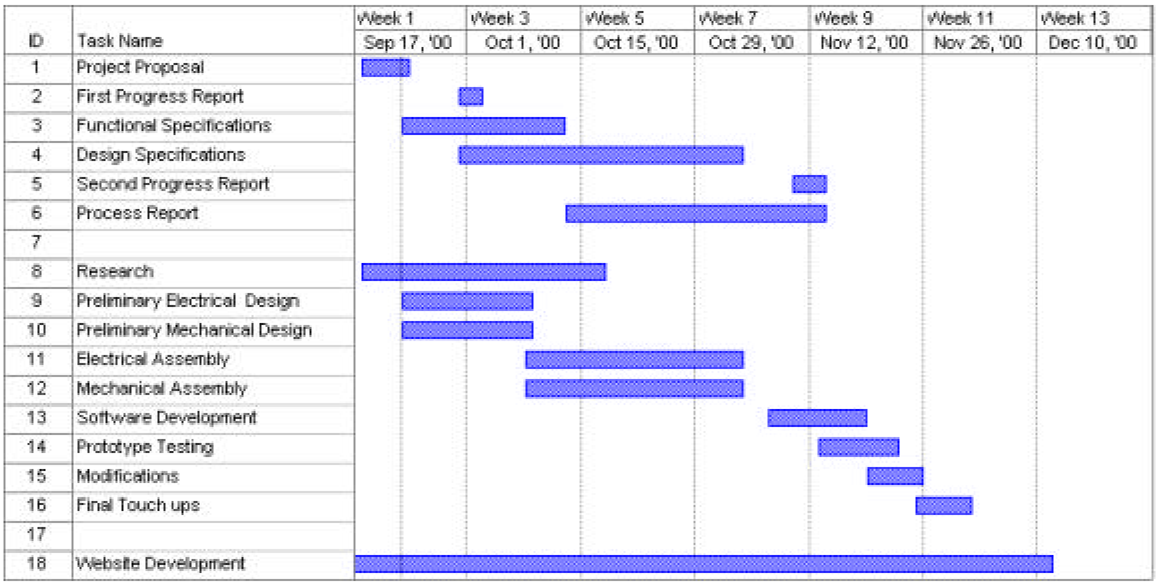

Figure 2: Gantt Chart

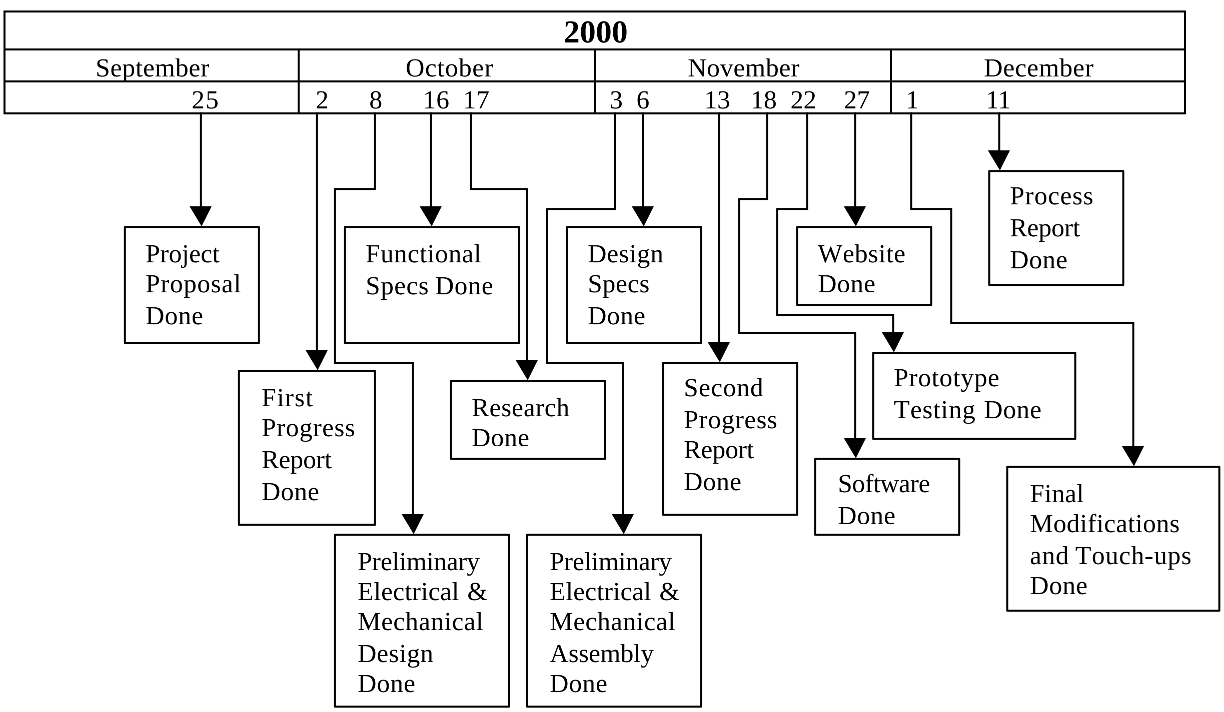

Figure 3: Milestone Chart

Team Organization

Perfect Pitch Instruments is comprised of three third year and two fourth year engineering students. We all have varying expertise and will therefore be able to contribute our knowledge and ideas in different areas. Our company is headed by Chief Executive Officer (CEO) Maria Trinh. Gina Millar and Terrence Yu are the Chief Financial Officer (CFO) and Chief Operating Officer (COO), respectively. Reva Vaze is Vice President of Engineering operations and Aaron Schellenberg plays the role of Chief Technical Officer (CTO).

Although each member has a designated position, all members of our company share equally in decision-making processes. To ensure that we are following the project schedule and meet our desired milestones we have set up a scheduled meeting time every week to discuss the progress of our work.

Company Profile

Maria Trinh, Chief Executive Officer

The Chief Executive Officer of Perfect Pitch Instruments is a third year engineering student, specializing in the systems option. She has substantial experience in both hardware and software design from her past four co-op placements, and has a great love of music projects. She designed and assembled the embedded system for an automatic jazz-piano tutor for the Technical University of BC. She developed the circuit schematics using Eagle software tools. She hand-soldered and wired all the circuitry, including a matrix of LEDs, and she developed the assembly code to run on the **M68HC05** microprocessor. She also implemented real-time, embedded **C** programming for the **M68HC332** at Creo Products Inc., which controlled the electronics and the hardware of Creo's plate-imaging machines. She also prototyped new surgical instruments and sensors for orthopedic surgery during her stay at the Vancouver General Hospital, where she learned the properties of bio-medical sensors/actuators and picked up machining skills. She picked up the guitar a year ago, which inspired her to build the automatic guitar tuner.

Gina Millar, Chief Financial Officer

Gina is a fourth year Systems Engineering Student at Simon Fraser University. She has had two previous co-op work experiences, one with Raytheon Systems and one with eCharge Corporation. Through both work and school she has gained a variety of software and hardware experience, though her strengths lie in low level assembly programming. She has a strong low level programming background on different microprocessors (8086, HC11, HC12), as well as sufficient high level experience with C++, Java, and Perl.

Terrence Yu, Chief Operating Officer

Perfect Pitch's COO is a third year Systems Engineering student at Simon Fraser University. His engineering abilities fall mostly in the software category, with experience in various software languages including C++, C, and TCL. His previous work experience includes two terms at Motorola, Inc. and one at Creo Products, Inc. Terrence has also been playing guitar for six years, and will therefore be able to give a user's perspective in the development of the product.

Aaron Schellenberg, Chief Technical Officer

Aaron is a fourth year Systems Engineering student at SFU who brings solid digital hardware design experience, as well as a mechanically inclined mindset. His hardware abilities include VHDL and Assembly coding, along with some practical hardware design skills. Aaron has played the guitar off and on for over eight years and is very enthusiastic about the project.

Reva Vaze, Vice President of Engineering operations

Reva Vaze is a third year electronics engineering student at Simon Fraser University. Most of her experience lies in hardware design testing, and was gained through working as a co-op student for Tantus Electronics and Silent Witness Enterprises. Although Reva does not play the guitar, she is interested in the music scene and will be able to provide a new user perspective during project development.

Conclusion

Perfect Pitch is convinced that their innovation will perk the interest of the guitar enthusiast at any skill level. By rendering the task of instrument-tuning much faster and easier for the novice guitar student, and by expanding the capabilities of the performing guitarist, Perfect Pitch believes that its automatic guitar tuner will meet the needs of many buyers in the musical instrument market.

The enthusiasm for this project is quite evident in our group, as the majority of the members are avid guitar players. Perfect Pitch is also excited about the technical challenges this project imposes, which indubitably exceed the expectations of ENSC 340. We are assured that upon completion of this course, we will have gained an extraordinary amount of product design and development experience, which will be highly beneficial to our future careers as engineers.

References

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2. www.sfu.ca/~mvolker

3. http://www.scitech.gov.bc.ca

4. http://www.apeg.bc.ca