*Instrument tuner*

Product Design Specification

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# Introduction

## Purpose of The Product

This product can be used to tune a stringed instrument to a specific tuning. Each string can be tuned to a target frequency by following LED indicators that show whether the string’s frequency is too low, too high, or on pitch. This provides a simple way for musicians to tune their instrument without needing to be able to recognize the target note by ear.

# General Overview and Design Guidelines/Approach

## General Product Overview

*This product is designed for the user to tune each string of their instruments one at a time. The user first plays a single string with the microphone close enough to pick up a sufficient audio signal from the instrument. The signal is sampled by the microcontroller, and the approximate frequency of the note is calculated. The frequency in the pre-selected tuning array nearest to the calculated frequency is selected as the target frequency, and the string corresponding to this note is indicated using the LED bar. The LED bar uses a single LED for each string, with the highest string on the right and the lowest string on the left. Finally, the on-board RGB LEDs on the microcontroller are used to indicate whether the calculated frequency is higher than (blue LED), lower than (green LED), or within the frequency tolerance range of the target frequency (red LED). The process of sampling the audio, calculating the frequency, and displaying relevant tuning information repeats on a loop, allowing the user to continually make tuning adjustments until they have achieved the proper note.*

## Assumptions / Constraints / Standards

For the current implementation of the product, our first assumption is that the instrument being tuned is a six-stringed guitar being tuned to standard tuning. However, more tunings with different numbers of notes can be added in the future, which nullify this assumption.

The next assumption is that the user can place the microphone sufficiently close to the instrument in order for the sensor to pick up an adequately strong audio signal. A signal that is too weak may give the wrong result or even produce no result at all. Similarly, we assume that the environment is reasonably noise-free; if the sensor picks up too much ambient noise, the frequency may be calculated incorrectly.

Finally, a frequency tolerance range of +/- 1 Hz has been used for determining whether a calculated frequency matches its target frequency. A 1 Hz discrepancy may still be detectable to a trained ear, and a smaller tolerance around +/- 0.5 Hz may be a more ideal choice for accuracy. The current tolerance range is a compromise for performance, as a greater resolution would require a faster sampling rate and a greater number of audio samples. It is also a compromise for the cheap microphone being used, which may struggle to differentiate finer changes in frequency.

# Architecture Design

## Hardware Architecture

The microphone detects the sound and captures it as a voltage waveform, amplifies this signal, and outputs an analog signal routed to the microcontroller’s OPAMP1 input. OPAMP1 applies a 2x amplification to the analog signal, and its output is routed to the microcontroller’s ADC1. The microcontroller timer TIM2 is used to generate timer interrupts in which ADC1 samples are collected and stored in software, thereby controlling the ADC sampling rate, which is set to sample 1024 samples at 4 kHz. When all samples are collected, the digital signal is processed in software, and LEDs on the LED bar are set via GPIOE 7 – 12 to indicate the target note and the onboard RGB LEDs are set via GPiOA9, GPIOB7, and GPIOC7 to indicate the relation between the target and calculated frequencies. Figure 1 provides a high-level hardware diagram outlining this process.

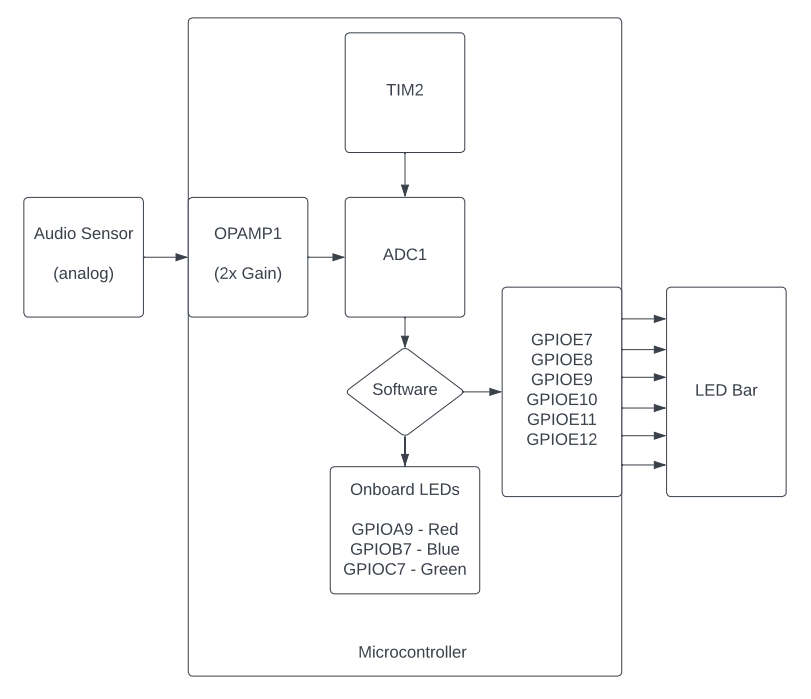


Figure : Hardware Diagram

## Software Architectur

[Insert any software architecture documents]

## Performance Considerations

The sound sensor module has small volume and low output noise; the fixed gain is 20dB. The sensor supports 3.3v and 5v. High-quality: Running the sensor on low power ensures longer service life.

This sensor is ideally suited for threshold measurement. This means that the sensor emits a digital high signal as soon as a threshold value set by the user is exceeded. However, this also means that the analog measured values are not suitable for conversions, as the analog signal is also influenced by the rotary potentiometer.

A lot of that should probably just be in the sensor description.

## POWER CONSIDERATIONS

Operating power 3-5V

Probably something about clock speed increasing power consumption for improved performance.

## SENSORS/aCTUATORS DESCRIPTION

This sensor emits a signal if the microphone of the sensor detects a noise. The sensitivity of the sensor can be adjusted by means of a controller.

Digital output: Via the potentiometer, a limit value for the received sound can be set, at which the digital output should switch.

Analog output: Direct microphone signal as voltage level

LED1 : Shows that the sensor is powered

LED2 : Indicates that a noise has been detected

FUNCTION OF THE SENSOR

This sensor has three functional components on its circuit board: The front sensor unit, which physically measures the environment and outputs it as an analog signal to the second unit, the amplifier. This amplifies the signal depending on the resistance set on the rotary potentiometer and sends it to the analog output of the module.

Here it is to be noted: The signal is inverted. If a high value is measured, this results in a lower voltage value at the analog output.

The third unit represents a comparator, which switches the digital output and the LED when the signal falls below a certain value. This value (and thus the sensitivity of the module) can be adjusted via the rotary potentiometer.

# System Design

## Use-Cases

[Insert any related project use cases]

## Data Conversions

[Insert any documents describing any necessary data conversions.]

## Application Program Interfaces

[Insert any application program interface documents.]

## User Interface Design

[Insert any user interface design documents or provide a reference to where they are stored.]

## Performance

[Insert any performance documents.]

## Bill of material (BOM)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Part Name | Part Number | Per Unit | Total Quantity Required | Unit Cost |
| [STM32 Microcontroller](https://estore.st.com/en/products/evaluation-tools/product-evaluation-tools/mcu-mpu-eval-tools/stm32-mcu-mpu-eval-tools/stm32-nucleo-boards/nucleo-l552ze-q.html) | NUCLEO-L562ZE-Q | 1 | 1 | $20.85 |
| [sound sensor](https://campaign.aliexpress.com/wow/gcp/tesla-pc-new/index?UTABTest=aliabtest377151_530968&src=google&src=google&albch=shopping&acnt=708-803-3821&slnk=&plac=&mtctp=&albbt=Google_7_shopping&albagn=888888&isSmbAutoCall=false&needSmbHouyi=false&albcp=19131229154&albag=&trgt=&crea=en2251832528996846&netw=x&device=c&albpg=&albpd=en2251832528996846&aff_fcid=7b8626e2b5a74daaa28589943a7d44bc-1682299304150-07178-UneMJZVf&aff_fsk=UneMJZVf&aff_platform=aaf&sk=UneMJZVf&aff_trace_key=7b8626e2b5a74daaa28589943a7d44bc-1682299304150-07178-UneMJZVf&terminal_id=d51c1082168946a39c05ba30e636096d&wh_weex=true&wx_navbar_hidden=true&wx_navbar_transparent=true&ignoreNavigationBar=true&wx_statusbar_hidden=true&bt_src=ppc_direct_lp&scenario=pcBridgePPC&productId=2251832528996846&OLP=1085100208_f_group2&o_s_id=1085100208) | KY-038 | 1 | 1 | $0.29 |
| [Jumper Wires](https://www.amazon.com/Elegoo-EL-CP-004-Multicolored-Breadboard-arduino/dp/B01EV70C78/ref=sr_1_2_sspa?keywords=jumper%2Bwires&qid=1682297804&s=industrial&sprefix=jumper%2Bwir%2Cindustrial%2C172&sr=1-2-spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExMlNPU0U2TzRKNjlaJmVuY3J5cHRlZElkPUEwOTQ1MDgyMVpYVDUwQlU5UzJKSSZlbmNyeXB0ZWRBZElkPUEwOTQ1MzIxMUVLUFZPSjk1OTFYOSZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU&th=1) | - | ~5 | 5 | $6.98 |

Needs LED bar, bread board, smaller jumper wire pack probably

## Calibration and test procedures

Calibration of the sensor potentiometer.

# Conclusion on

[Summarize your experience with this project. What challenges you faced, did you mean the specifications, any ways to improve]

Appendix A: References

[Insert the name, version number, description, and physical location of any documents referenced in this document. Add rows to the table as necessary.]

The following table summarizes the documents referenced in this document.

|  |  |  |
| --- | --- | --- |
| **Document Name and Version** | **Description** | **Location** |
| *<Document Name and Version Number>* | *[Provide description of the document]* | *<URL or Network path where document is located>* |

Appendix B: Key Terms

*[Insert terms and definitions used in this document. Add rows to the table as necessary. Follow the link below to for definitions of project management terms and acronyms used in this and other documents.*

*http://www2.cdc.gov/cdcup/library/other/help.htm*

The following table provides definitions for terms relevant to this document.

|  |  |
| --- | --- |
| **Term** | **Definition** |
| *[Insert Term]* | *[Provide definition of the term used in this document.]* |
| *[Insert Term]* | *[Provide definition of the term used in this document.]* |
| *[Insert Term]* | *[Provide definition of the term used in this document.]* |