*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).*

## Assumptions / Constraints / Standards

Design Assumptions:

1. The instrument being tuned is a guitar.
2. The user does not strum a cord (assumes a single frequency)
3. The sound sensor is within a close distance to the instrument.

# Architecture Design (At least one block diagram is required in this section)

This section outlines the system and hardware architecture design of the system that is being built.

[Describe the system architecture, how the application interacts with other applications. Not necessarily how the application itself works but, how the appropriate data is correctly passed between applications.]



## Hardware Architecture

The microphone amplifies the signal and outputs an analog signal routed to the microcontroller’s opamp input. The microcontroller opamp applies a 2x amplification to the analog signal, and its output is routed to the microcontroller’s ADC. A timer interrupt is used to control the ADC conversion rate, which is set to sample at 4 kHz. The ADC output is saved in software to an array.

## Software Architecture

[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 (required section)

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) (required section, include only component that are part of your product)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 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 (required section)

[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.]* |