Audio Amp/Speaker Block Validation

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1. Description

An audio Deterrent mechanism utilized to repel birds away when activated with an effective audio sound. If sensors detect bird movement the system control will activate the audio amplifier for a set duration using a sound best used for deterring birds without causing harm to them and with minimal disturbance to surroundings.

2. Design

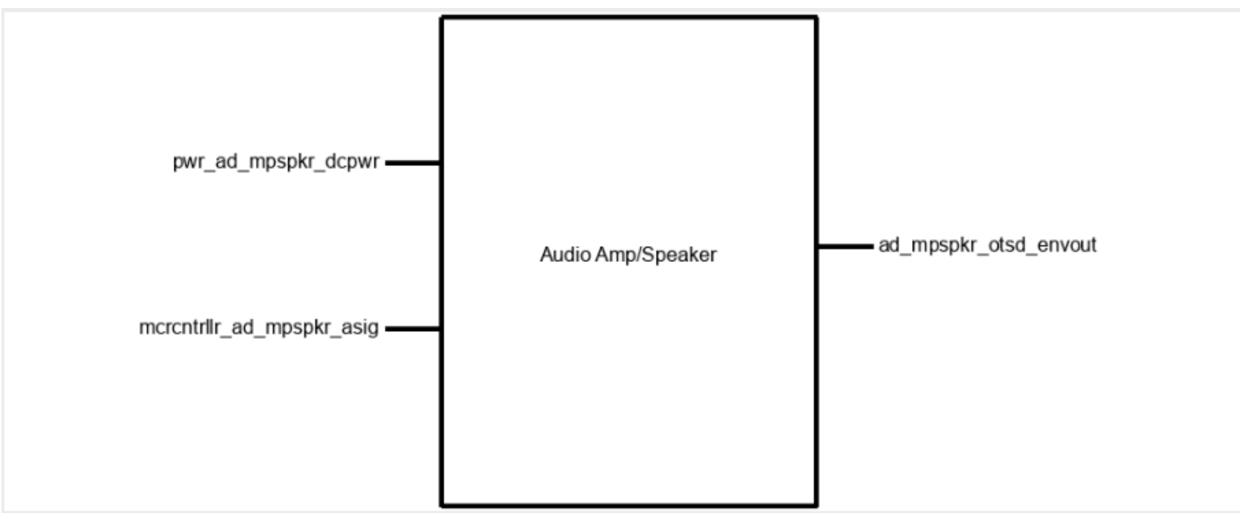

Figure 1: Black Box Diagram

Figure 1 above illustrates all the Audio Amplifier's input and output interfaces. For the Audio amplifier's black box inputs there is the power supply to speaker connection pwr_ad_mpspkr_dcpwr which supplies DC power to the device and all other blocks including the microcontroller and audio amplifier. The mcrcntrllr_ad_mpspkr_asig interface turns the audio amplifier on when a bird is detected. For output there is the environmental output ad_mpspkr_otsd_envout interface where the speaker is activated to alert incoming birds.

For the purposes of being capable of consuming low power and to output lower frequencies, an operational amplifier circuit using a low voltage audio amplifier such as an LM386 was drafted to be the initial design for the audio amplifier. In Figure 2 below each pin function is labeled for the LM386 operational amplifier. The LM386 used is an N-1 part, which has lower overall voltage specifications and is ideal for the project's power constraints.

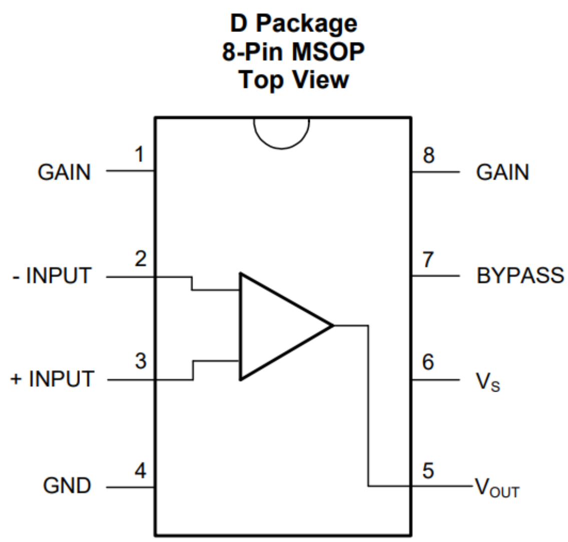

Figure 2: OpAmp Pin Configuration and Functions

Speaker components have been chosen as well as small components for building the OpAmp circuit such as capacitor and resistor values. Connection from microcontroller audio pins use low pass filter components using a 100 nano-farad capacitor, C1 as well as C2, and 1000 Ohm resistor in series, R1 as well as R2, for each audio pin connecting to the microcontroller. Both low pass filter connections connect to the operational amplifier's input pin 3. Both Opamp's gain pins are not needed and left with no connection. Input pin 2 connects to ground for the opamp. Power supply connection connects to Vs pin 6 with a 100 micro-farad capacitor, C3, connected to ground across the power supply connection, which was chosen for a higher voltage relative to the voltage rating for the LM386. The bypass pin 7 connects to ground across another 100 micro-farad capacitors, C4. Ground pin 4 also connects directly to ground with no added connections for pin. Finally, Voltage output pin 5 connects to speaker across a 1000 micro-farad capacitor, C6, alongside connection to ground across a 100 nano-farad capacitor, C5. All descriptions for the operational amplifier's pin connections are show in the schematic in Figure 3 below.

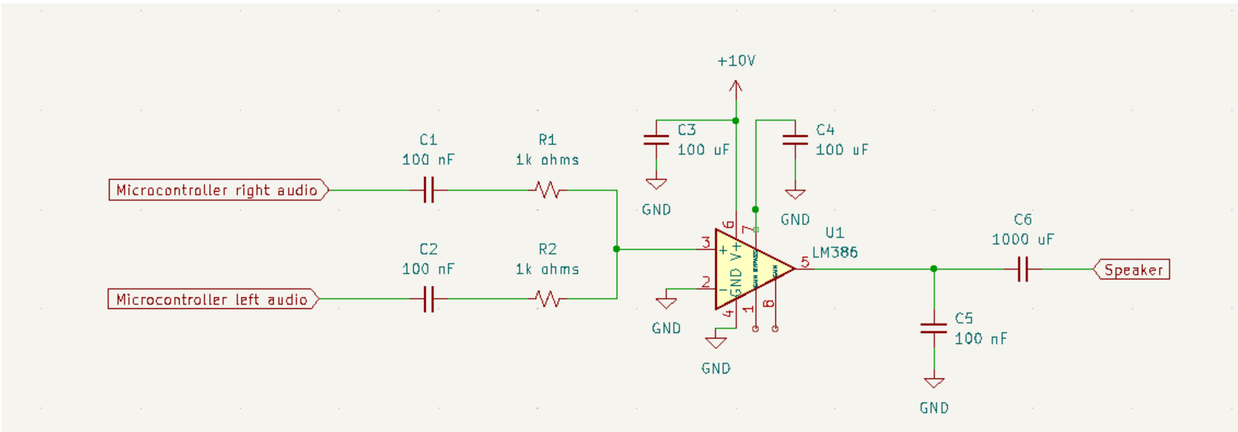

Figure 3: OpAmp Circuit Schematic

Power specifications from the project's power supply block are currently 10 V for nominal voltage as well as 3 mA for nominal current necessary to satisfy being operational for the system. The system can also operate with nominal voltage as low as 5 volts, which may be necessary moving forward to accommodate constraints currently with the power supply block. For the current design and testing 10 volts will be the nominal voltage for operating the block. Current frequency estimated to be required for desired result from output is between 4 KHz and 10 MHz. Ideal audio frequency is yet to be decided without making the requirement a constraint and serving the needs of the project for finalizing the device's functionality, so future adjustments will update the required range of frequency the audio amplifier will operate under. Further design additions and changes will be considered moving forward in the design process.

Bill of Materials

Components	Quantity
LM386N-1	1
Speaker	1

Testing	
Breadboard	1
Audio Jack cable	1
9V battery	1
.1 uF Capacitor	3
100 uF Capacitor	2
1000 uF Capacitor	1
1k Ohm Resistor	2

Figure 4: OpAmp BoM

For at home testing a 9-volt battery will be used and for verification demonstration purposes a breadboard will be used alongside an audio jack cable to connect to the microcontroller or for testing purposes a phone or mp3 player to test audio output from operational amplifier device. Testing materials and Opamp components are listed in the Bill of Materials for Figure 4 above.

3. General Validation

The first design choices to consider are if an AC or DC power audio amplifier are needed, if the system requires multiple speakers, and if an audio board needed to be considered for user input audio control to increase, decrease, and turn off sound from the speakers on the device. AC powered audio amplifiers are much more complex to design and implement as opposed to the cost-efficient options DC powered audio amplifiers offer, therefore due to the marketability constraints of the project the more simplistic and cheaper option was chosen for the audio amplifier to run on a DC powered design. The system only requires one speaker so long as the speaker can produce sound audible for nearby birds to hear, and no volume control from a user's input was deemed necessary for the purposes of the project design, so no audio sound control board was implemented in the design for the audio amplifier.

The amplifier must meet the power specifications and frequency to drive sound sufficient for alerting a bird, so an LM386N-1 was chosen as an affordable DC operational amplifier to drive sound from a microcontroller to a speaker. I chose a simple operational amplifier circuit for each specification as a basis for design. Using a low pass filter across microcontroller inputs into the opamp would clear the audio frequency output further, which was why two low pass filters across each audio pin was ideal for higher frequency sounds such as universal bird calls to alert danger or louder construction noises. Any higher pitch deterrent will be accommodated from the filter input design choice, which allows for flexibility and range from the design to output several kinds of deterrent sounds in case the project's current deterrent output sounds show to be insufficient. From the bird deterrent project device's marketability requirement, the device requires a compact design with as lightweight components as possible. Given that the device must be compact, lightweight and has low demand on what is required for the audio amplifier to perform its function, this justifies a minimalistic setup that can meet the power supply and microcontroller's specifications.

The LM386N-1, according to the datasheet found under section 6 of the document, is rated to operate between 4 to 12 volts, which allots for flexibility for the device's power supply design. The current state of the project's power supply block is undergoing optimization changes and power constrictions, which may require voltage requirements to change to satisfy a lower minimum and maximum voltage threshold between 4 to 6 volts. The device has been rated and tested under lower voltage conditions without dropping in sound or sound quality, which allows the device to be carried over with minimal to no changes if the power supply adjustments are necessary for the project moving forward. More cost-efficient components such as resistors and capacitors were used in the design to further accommodate and satisfy marketability requirements without compromising the device's sound quality. The device in testing was operating with a speaker capable of high frequency output enough to be audible throughout a given room. Bird's ears have a much greater heightened sense of hearing, which greatly reduces the required frequency output necessary to alert a bird from a distance needed to give the bird a sufficient reaction time to respond to the sound. With the device operating with an ideal speaker sound output and under sufficient lightweight conditions of the block, and the device being operational between 4 and 12 volts as rated from the LM386 datasheet and tested with a voltage load, the conditions have been satisfied across each relevant project requirement and block interface until further blocks are developed.

4. Interface Validation

Below are interface properties defined for the devices input and output values, a description of why these are interface values for the interface property, and how the design can meet or exceed the specifications for each interface property. For input acdc_cnvrtr_pwr_spply_ad_mpspkr_dcpwr nominal current, Inominal, is desired to operate at about 3 mA. Peak current, Ipeak, maximum value is measured to be 300mA. Maximum voltage, Vmax, maximum value is measured to be 3.3 Volts. Minimum voltage, Vmin, minimum value is measured to be 3.3 Volts. Ripple voltage, Vripple, estimated value is measured to be .2 Volts. For input systm_cntrl_mcrcntrllr_ad_mpspkr_asig, Nominal Frequency is measured to be about 4 KHz. Maximum voltage, Vmax, maximum value is measured to be 3.3 Volts. Minimum voltage, Vmin, minimum value is measured to be 3.3 Volts. For output ad_mpspkr_otsd_envout, expected frequency output is measured to also be about 4 KHz.

Interface Property	Why is this interface this value?	Why do you know that your design details for this block above meet or exceed each property?
acdc_cnvrtr_pwr_spply_ad_mpspkr_dcpwr : Input		
Inominal: 3mA	Amount power supply is designed to support	Leave device block operational measuring approximately close to Inominal on average
Ipeak: 300 mA	Amount power supply is designed to support	Leave device block operational measuring no higher than Ipeak
Vmax: 10.3 V	Amount power supply is designed to support	Leave device block operational measuring no higher than Vmax
Vmin: 9.7 V	Amount power supply can be designed to support	Leave device block operational measuring no lower than Vmin
Vripple: .2 V	Amount power supply can be designed to support	Leave device block operational measuring approximate to Vripple
systm_cntrl_mcrcntrllr_ad_mpspkr_asig : Input		
Nominal Frequency: Frequency: 4 KHz	The frequency needed to alert a bird audibly from a further distance	Check if audio amp speaker can produce sound with frequency of 4 KHz
Vmax: 3.3 V	Amount power supply can be designed to support	Leave device block operational measuring at roughly Vmax
Vmin: 3 V	Amount power supply can be designed to support	Leave device block operational measuring at roughly Vmin
ad_mpspkr_otsd_envout : Output		
Other: Frequency: 4 KHz	The frequency needed to alert a bird audibly from a further distance	Check if audio amp speaker can produce sound with frequency of 4 KHz

5. Verification Plan

*(edit steps to be more specific step by step, clear instructions)

A: Power Supply Testing

1. Power on device by plugging 9-volt battery or power supply into device ground and the C1 100uF capacitor.
2. Power on voltage load and place probes onto power supply connections.
3. Measure Vmax and Vmin then verify if values meet specified properties measurements.
4. Also verify if Inominal and Ipeak meet specified properties measurements.
5. If all interface properties measurements satisfy conditions the test passes.

B: Audio Amplifier Output Testing

1. Turn on Oscilloscope for measuring device frequency output.
2. Connect Oscilloscope probes to Device.
3. Adjust Oscilloscope to view frequency and auto set display.
4. Adjust screen by lowering amplitude of the signal.
5. Verify if resulting frequency output meets within threshold of desired frequency for device.
6. If all interface properties measurements satisfy conditions the test passes.

C: Microcontroller to Audio Amplifier Testing **needs external blocks further developed to test fully**

1. Power on audio amplifier speaker.
2. Play a sound using microcontroller or other device for testing speaker's audio output.
3. Play bird call or construction sound audio clips on microcontroller or other test device to play sound on audio amplifier.
4. If device is audible from 10 ft the test passes.

6. References and File Links

LM386 Datasheet:
https://www.ti.com/lit/ds/symlink/lm386.pdf?ts=1674260774336&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FLM386%253FkeyMatch%253DPC817

Speaker Datasheet:

https://resi.store/products/346/speaker.pdf

7. Revision Table

1/20/2023	Kalynne Whited: Document created and edited for rough draft submission
2/7/2023	Kalynne Whited: Made initial edits from peer review critiques for Design section and annotated additional changes to be made throughout document.
2/8/2023	Kalynne Whited: Redefined and edited interface properties and added speaker datasheet link
2/9/2023	Kalynne Whited: Further detailed verification plan A and B
2/10/2023	Kalynne Whited: Added more detailed explanation for design section of audio amplifier block document
2/11/2023	Kalynne Whited: Added a further detailed explanation to general validation and interface validation sections of the document.
2/11/2023	Kalynne Whited: Finalized document before submitting block 1 validation to canvas.