Project Closeout

Team 3: Electrical Arc Speaker

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Design Impact Statement

The purpose of this assessment is to evaluate the potential impact of the electrical arc loudspeaker project, analyze the potential negative (positive) impact, and provide reasonable solutions and recommendations. The report will first provide the basic information and framework of the project and report the impact assessment of the project design from the four aspects: public health and safety, social impact, environmental impact, and economic factors.

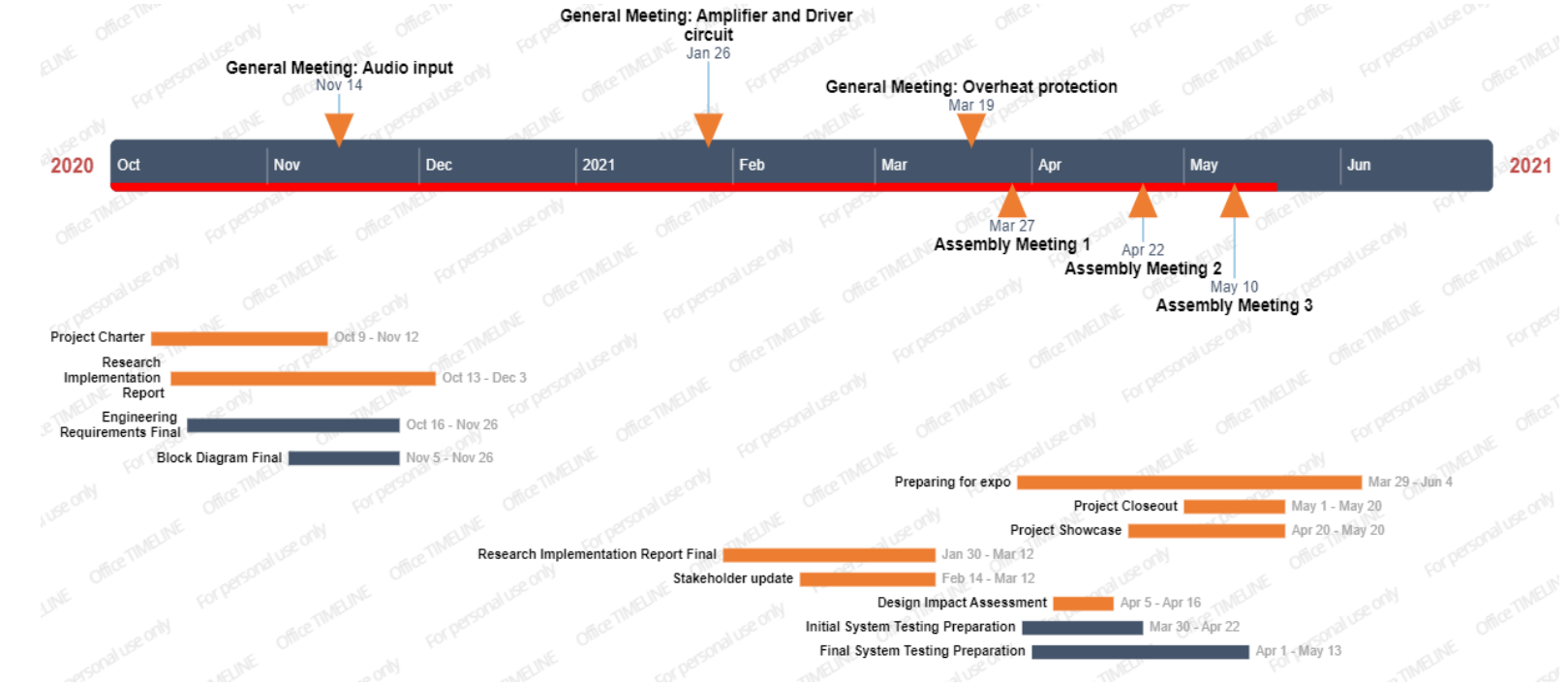
Our team took safety into the top consideration during the design, including the overheat protection, dual switch, and temperature detection module. We choose a closed enclosure and ensure that the connection gap is less than 1cm to ensure the smooth transmission of sound and maximum protection. The potential public health impact included human health hazards from ozone generated by electric arc discharge [1]. Most air molecules are neutral under normal conditions, and these neutral molecules will be converted into charged particles after high voltage discharge.

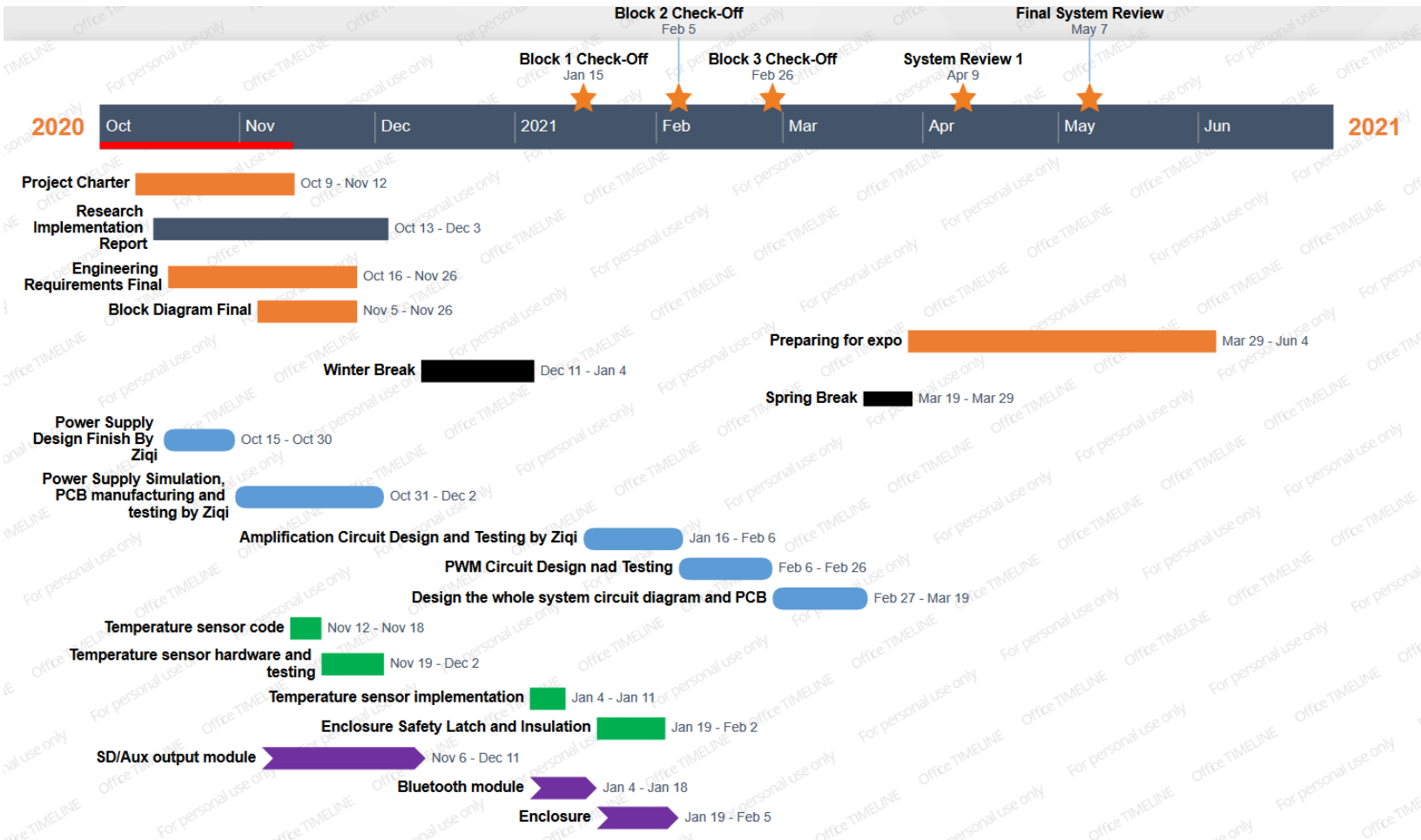
The team believes that the electrical arc speaker device is an extension of the loudspeaker equipment in real life, and therefore will not have a drastic impact on existing culture and society. Although the device has limited cultural implications, the team expects it to change the way people live in some ways. There is evidence that most teens prefer headphones to speakers; however, headphones aren't perfect and can cause hearing problems more than speakers. According to TeenHealth about earplugs: “Hearing loss from earbuds is an example of a condition called noise-induced hearing loss (NIHL). This kind of hearing loss is becoming more of a problem among kids and teens” [2]. The team hopes that the high-pitched plasma speaker will change people's preferences in a way that could have a positive impact on hearing health.

Ozone is produced by ionization of the air during the operation of plasma loudspeakers. Even with the low power of a home using a speaker, the team hopes to explore the potential environmental impact of the ionization reaction. According to a paper published by the American Environmental Protection Agency, ozone may cause plants to reduce photosynthesis and slow plant growth. Some sensitive plants are more susceptible to pests and diseases [3]. The rate and total amount of ozone produced by household electrical arc speakers are very low. The team advises users to adjust the speakers to the appropriate volume and turn off the speakers when they are not in use.

The electrical arc speaker is a loudspeaker that uses an electric arc to vibrate air and produce sound. The design inspiration and purpose come from restoring the essence of sound with more advanced methods. The arc loudspeaker's principle is to convert sound signals into electrical signals and vibrate through an arc [4]. The electrical arc loudspeakers are not a product of the 21st century. In fact, they have been used for arcing sound since 1900. Their advantages include more fidelity, less transient reality, and more high-frequency capability. However, we rarely see it in real life, and it has not been completely commercialized. The team believes that the electrical arc loudspeakers offer good investment value and have a potential economic impact.

Project Timeline





Scope and Engineering Requirements

Name	Engineering Requirement detail
Additional Inputs	The system will allow for sound from Bluetooth and an SD card without a user needing to reconfigure the system.
Audio Identifiable	The system will play "The Beaver Fight Song" of the system, and the song can be identifiable by 9 out of 10 users.
Audio Output	The system will play the Beaver Fight song with an option to play the song again heard at a level of at least 55 dB from 5m away.
Bluetooth Audio Input	The system must allow cellphones to connect and play audio
Enclosure	The enclosure must be transparent and fully surround the whole system with openings being 1cm or less at its longest point.
Overheat Protection	The system must have heat sensors and will shut down if any circuitry exceeds a threshold temperature of 90℃.
Power Switch	The system must have the main switch to disconnect the power immediately along with a safety interlock to turn it off if the latch is open
System Reliability	The system will generate an arc for over half an hour.

The electrical arc speaker system consists of three main blocks: audio input, safety detection, and audio modulation with power amplification. The audio input will be set up on an independent module and will be provided with Bluetooth and SD card two input options. Users can choose from two audio modes by simply pressing a button on the system enclosure without any internal resetting. Safety detection consists of two parts, microprocessor sensor, and code. It will conduct temperature detection and provide monitoring services based on each IC and voltage regulator in the circuit. The audio modulation system converts the audio signal into a PWM signal, and the power amplification system is responsible for amplifying the input PWM signal and making it have enough power to drive the high-voltage transformer. The audio input and audio modulation modules will be set up independently in the two PCB boards and communicated via the AUX cable.

Risk Register

Risk ID	Risk Description	Risk Category	Risk Probability	Risk Impact	Performance Indicator	Responsible Party	Action Plan
Hermes	Shipping delays caused by express companies or merchants	Timeline, COVID	75%	L	Tracking information on packages	Aaron will keep track of shipping times	Retain, order early
Zeus	Damage to electronics from high voltage or heat	Technical	10%	H	PCB stops working	All will make sure parts have proper spacing and insulation	Reduce, design with high voltage in mind
Hades	High current can cause severe injury to those working on the project.	Human	Very low	H	...	All will practice proper safety	Reduce, use safety precautions
Apollo	The system is underpowered and cannot drive high frequency voltages	Technical	10%	M	Can't hear speaker from 5m away	Ziqi will calculate and test the amplifier voltage	Avoid, create new amplifier
Aphrodite	The enclosure may be designed without discussed parts being displayed.	Design	Low	M	Arc or PCB not visible	Annie will design an aesthetic enclosure with a clear front	Avoid, redesign enclosure
Plutus	The total cost of the materials may exceed the proposed budget.	Cost	10%	L	Total cost of project is over $300	All will look for cheap, but good quality, parts	Retain
Hephaestus	The modules may not be compatible when implementing the final system.	Technical	10%	H	Signal from one module not accurate in the next	Ziqi will simulate the modules together	Avoid, order new parts
Ares	The speaker could be	Physical	Low	H	Visible damage or	All will transport	Reduce, keep speaker

	damaged by transportation or other external factors.				cracking noises	speaker safely and make sure it won't fall	on stable surface

Future Recommendations

1. A smaller size system

The dimensions of the system are not specified in our engineering requirements. Our current system size is 37*34*37 (L*W*H in cm), which is obviously hard to carry and move. In the stakeholder analysis, our team mentioned that the smaller size might bring more purchase desire, but based on the project schedule and overall planning, our team finally abandoned this additional requirement.

Recommendation

When designing, consider the layout of the PCB and the overall equipment arrangement. Carefully select the electrode which can horizontally set into the enclosure to reduce the height of the device.

2. Set up internal batteries

Setting up internal batteries was not part of the team's engineering requirements, nor was it requested by the project partners. Consider that conventional speakers on the market usually have internal rechargeable batteries for portable playback. This is one of the engineering requirements that can be added in the future, which is also conducive to bringing stronger competitiveness to the product in the market.

Recommendation

The choice of battery is very important. The AC-DC transformer that our team is currently using is 24V-6A, and the power of the whole system is about 120W. The selection of the battery should take into account the voltage requirements of the system and the high enough current to withstand while ensuring a minimum battery life of 30 minutes system running. The team suggests considering high-capacity lithium-ion batteries, which allow for both battery weight and voltage requirements.

3. Design One PCB contains all modules

“The One PCB” is the most ideal system state, because it will greatly save the volume (size) of the system, and this is also one of the expectations of our team project partners. Our system mainly contains audio input, amplifier and drive circuit, and microprocessor overheating protects three modules. It is difficult to design a piece of PCB containing all the modules because it requires each member to coordinate at the best and design it at the same time, and also has a high failure rate. Due to the epidemic, team members could not meet frequently. In addition, there were situations of different time zones and remote cooperation among teams, so all the team members decided to abandon this plan.

Recommendation

It was a big challenge to design all the parts on one PCB, and this requires a high degree of collaboration among team members. The team recommends designing each part in advance and giving at least two months to design the final PCB. A PCB with multiple features typically takes more time to design and debug, so pay attention to the overall project schedule and

timeline. An even simpler approach might be "plate splicing," a service offered by some PCB manufacturing companies that combine different PCB boards onto a single board.
The team recommends that when using this approach, pay attention to the interface design on each PCB, and consider the placement of components to make it easier for you when tidying up the cables.

4. A louder speaker

One of the engineering requirements of our team was to have a sound intensity of at least 55dB at five meters from the system. This is a normal speaker sound level, and the engineering requirements were approved by the project partners. In actual tests, the system has a sound intensity of about 60dB at 5m. Our team believes that the system is good enough for normal indoor use, but if used outdoors or at a party, the sound intensity is still not enough. Thus, raising the volume of the system could be one of the suggestions for future improvement.

Recommendation

There are two main aspects to improve the volume of the system, one is the design of the amplifier, the second is a higher power. Increasing power is the most straightforward approach, but the power consumption and choice of AC-DC transformers or future batteries must be taken into account. The audio amplifier is one of the components that determine the sound quality and volume of the system, and the team suggests either using A combination of Class-D and Class-A amplifiers or designing multiple amplifiers to further amplify the volume.

5. Smart home with WIFI connect

WiFi connectivity is a modern trend for household appliances, and now an increasing number of families are opting to set up smart homes. WiFi connectivity could be part of future engineering requirements, and this is a nice extension based on home appliances. At present, our system supports AUX, SD Card, and Bluetooth three connection modes, and the team believes that more connection modes are conducive to occupying a favorable position in the market. The device supports WIFI, which makes it easier for users to detect the system and achieve ultra-long distance control.

Recommendation

There are various ways of WiFi components. Our team suggests using the combination of microprocessor and WiFi devices in future improvement. The user can detect the temperature and status of the system on the mobile terminal, and control the playback of the song at the same time. There is not much difficulty in building WiFi on the hardware side, but it requires a lot of effort on the software side. The setting of the software side determines the user's access to remote control, and giving more functions to the user means that more programs need to be included in the microprocessor.

6. The display screen

In the overheat protection engineering requirement, our team met the requirement of interrupting the system when the chip exceeded 90 degrees Celsius and restarted it when the system was below our setting temperature. A more intuitive way to do this might be to use a

screen that shows the current PCB temperature. At the same time, the system can also transfer the data to the user's mobile terminal in real-time through the WIFI device of Smart Home.

Recommendation

Monitoring system temperature through the display is easy to implement, but given the previous Smarthome requirements, users can control the system remotely from a mobile terminal. The choice of the microprocessor is worth considering, it needs to meet both output and input ports, and has a matching temperature sensor and WiFi device.

7. Ozone detector

In the process of ionization of oxygen in the air, ozone will be released. As for the harm of ozone to the environment and humans, our group has discussed this part in the impact assessment. The team believes that an ozone detector is a valuable component that could be considered for inclusion in future engineering requirements.

Recommendation

At present, the mainstream microprocessors in the market do not have the supporting ozone detection module and the cost of this module is a problem worth considering.
The team recommends selecting an ozone detector with a built-in WiFi module and being able to transmit the data to the system's microprocessor. One point worth considering is that this requires the WiFi module of the system microprocessor to meet both input and output modes, and the workload of the software level is also worth noting.

8. Automatic ON/OFF and alarm support

Many stereos currently on sale support alarm mode, including brands such as Philips, Panasonic, and Amazon. Consumers are more likely to want the speaker to be "more than just a speaker", and our team believes that adding an alarm clock to the speaker is a mainstream development trend and could be a future engineering requirement.

Recommendation

A necessary module for this function is the timer, which can be the real-time clock obtained from the Internet through WiFi, or the internal timer built in the microprocessor. Both directions can meet the engineering requirements of timing and alarm functions required. The team recommends using both an internal timer, whose advantages lie in its ability to run offline and its stability, and an Internet model, whose advantages lie in its accuracy. Considering that sometimes the system will encounter WIFI interruption or poor network, it is necessary to set up the built-in timer. At the same time, in view of the possible inaccuracy of the internal timer, the Internet time can be used to adjust the final display time of the system.

References

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