Optimising speech intelligibility for casting, through the design and build of a tailored multi-band EQ

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Introduction

Intelligibility of spoken content in a web-casting is vital in producing a quality production. This quality factor within casting depends on factors such as the dynamic control in different environments against background noise and room acoustics, the speaker's characteristics and emotion, and in the digital transmission and encoding of the speech audio signal (Armstrong, 2011)(Rodman, 2006).

This project follows the design and build of a hardware, analogue equaliser (EQ), designed to improve the speech intelligibility of voice casting. In conjunction to this, the dynamic control of this device is be a key parameter in containing tonal distortion amplitude relationships. The characteristics of human speech production forms the basis of supporting information into the design of the optimised frequency spectrum alterations for intelligibility. The scope of the project was to provide a user friendly, cost effective and dynamically sized device to provide consumer level casters with the ability to optimise their ineligibility, in any environmental circumstance.

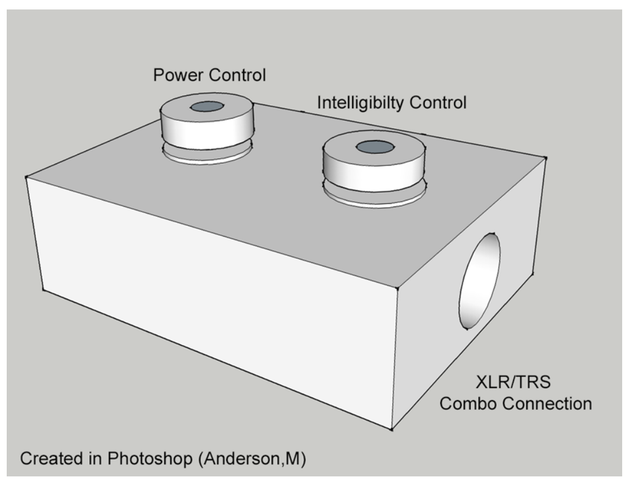

Figure 1— Final Product Design

Aims

1. Design and Build of a Multi-Band Equaliser
2. Design the optimal frequency spectrum response for speech intelligibility, whilst retaining sonic qualities of the user and control of voice dynamic.
3. Run a plethora of tests on the device to highlight its performance metrics.
4. Implement research into speech intelligibility and issues in casting, informing the projects outcome.
5. Collate and evaluate final project outcomes against initial proposed criterion.

Objectives

Detailed below are the technical objectives for the equaliser in this project.

Parameter	**Specified Value**
Frequency Response	20Hz-20kHz (With appropriate alterations for optimisation of speech intelligibility).
Input/output	±15dB
Dynamic Range	≥90dB
THD+Noise	<1%
Gain Control	±6dB

Table 1 — Technical Objectives

Method

Comprehensive research was carried out into the human production and recognition mechanisms along with their characteristics relating to speech intelligibility. This highlighted the frequencies areas that can be manipulated to optimise intelligibility. The determination of two frequency bands was formulated to give controllable parameters on the device, The two frequency bands implemented into the design of the equaliser were speech 'Power' (500Hz-800Hz) and 'Intelligibility' (800Hz-3kHz) (McLoughlin, 2009). The circuit was primarily based off of a graphic equaliser design (Franco, 2015). The circuit was simulated using Autodesk EAGLE spice simulator to the display the frequency response for the circuit. This gave strong indications that the chosen circuit design is suitable to be utilised in the build stage of this project.

In parallel to, this virtual preliminary testing using a DAW and a channel EQ plug-in to simulate the effect of the equaliser's output gave reinforcing results both subjectively and objectively that the filters response's improve intelligibility. This was utilising a MOS (Mean Opinion Score) and DRT (Diagnostic Rhyme Test) set against varying background noise and environments . The initial circuit design was built onto a breadboard and then later soldered to perf-board to complete the initial prototype.

The prototype was tested using the NTI Flexus to highlight the technical objectives of the project.

Results

The preliminary virtual testing found results that the plug-in equaliser simulation was successful in improving intelligibility subjectively and objectively in relation to different background noises and environments. The simulation stage reinforced the success of the circuit design for producing the required frequency response and outlined the filters characteristics and gain control value. The prototype testing yielded unsatisfying results in relation to the technical objectives as issues with the summation stage of circuit were identified. Unfortunately due to time constraint the fully realised final prototype was not able to be completed.

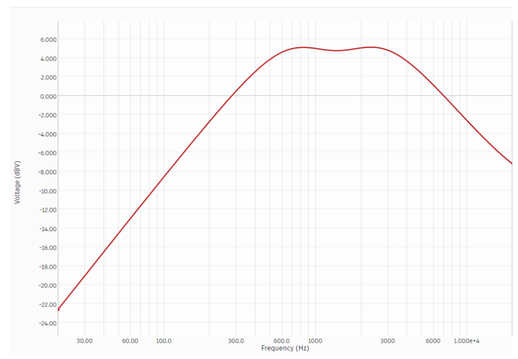

Figure 2 — Full equaliser circuit simulation

Conclusion

Despite the failure in producing a finished product, the concept and designing stages of this project ultimately concluded success in relation to the aims. The design is fully supported by comprehensive research and reasoning that the manipulated frequencies in the equaliser optimise the speech intelligibility of the human voice in the web-casting environment.

- McLoughlin, I., 2009. *Applied Speech and Audio Processing: With MATLAB Examples.* 1st ed. Cambridge: Cambridge University Press.
- Franco, S., 2015. *Design with operational amplifiers and analogue integrated circuits.* 4th ed. New York: Mcgraw-Hill.
- Armstrong, M., 2011. *BBC Research White Paper WHP190 Audio Processing and Speech Intelligibility,* s.l.: BBC.
- Rodman, J., 2006. *The effect of bandwidth on speech intelligibility.* s.l.:Polycom.