

Cochlear Implant Project:

Evaluation Method

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In the design of a reliable and correctly functioning cochlear implant, a strong evaluation method is needed in determining how well the implant accomplishes its task. This allows for engineers to know what they are designing for, and establishes hard requirements that need to be met before the product can be sold (or in this case implanted). If those requirements are not met, the results of the evaluation can be used to assess how it can be improved in future iterations.

The evaluation for this specific project aims to assess the ability of the implant to process audio signals and convert them to an output that can be sent to the cochlear nerves. The evaluation process will involve inputting several audio recordings into the system (which will be modelled in MATLAB) and evaluating the output according to the evaluation criteria outlined below.

It is important that the implant is able to perform in all auditory conditions, not just ideal ones. It needs to be able to process and convey conversation and human speech to the user in a variety of scenarios and situations. To account for the diversity of human speech and different auditory environments, a variety of complications were introduced into the audio recordings to simulate situations that may be encountered while using the implant.

To ensure that a wide range of situations were accounted for, 2 variable factors were controlled in each recording. These included background noise level and type, and pitch of the voice in the recording. Background noise level was split into 3 categories: quiet, conversational background noise, and street background noise. Pitch of the human voice was also split into 3 categories, low pitch, regular pitch, and high pitch. Along with these two variable factors, two different tests were performed. One that focused on isolated word comprehension, while the other focussed on comprehension of fluid and dynamic conversation. These are expanded

upon in the next paragraph. To gauge the impact of each variable, audio recordings were created with almost every possible combination of variables for each test. This allows for the system to be assessed in a multitude of scenarios and inform any future design decisions or modifications that may need to be made.

The first part of the proposed evaluation method involves a subject rating the sound quality of a conversation on a scale from 1 to 5, as defined by the rating guidelines in Table 1: Conversation Rubric. The average score from the participants will be used in the final calculation. Participants will be asked to listen to the output audio of the system and judge how difficult it is to comprehend the conversation. This test judges the functionality of the device when using it for its intended purpose; processing a real world conversation. For this reason this test is weighted with higher importance compared to the quantitative test described in the next paragraph.

The second testing methodology is a more objective and quantitative measurement of the implant system. The audio input to the system will be a list of 15 different words all of varying syllables and sounds. A random participant will be told to listen to the reconstructed audio from the system without hearing the original audio clip. They will attempt to identify the original word input into the system for each of the 15 different words (see the word list below). The number of correct comprehensions will be tallied and scored out of 15 to result in a final percentage value.

To get a final percentage score for each design, a weighted average will be used as laid out in Table 2. Conversational input is more relevant for the intended use of the system, as the implant is intended to be used for full conversational comprehension, and so it will be weighted more heavily. The conversational score will be weighted at 60% with the individual word score being weighted at 40%. This final weighted score will be used to determine the design with the best overall performance.

Table 1: Conversation Rubric

Rating	Description of Rating
5	Speech is clear and easy to understand, easily comparable to regular human speech.
4	Conversation is well understood, and the majority of words can be identified.
3	Conversation can be vaguely followed, but many details are not understood. Many words are not understandable.
2	Unable to understand the conversation, but audio is identifiable as human speech. Few words are understandable.
1	Unable to tell the audio is human speech.

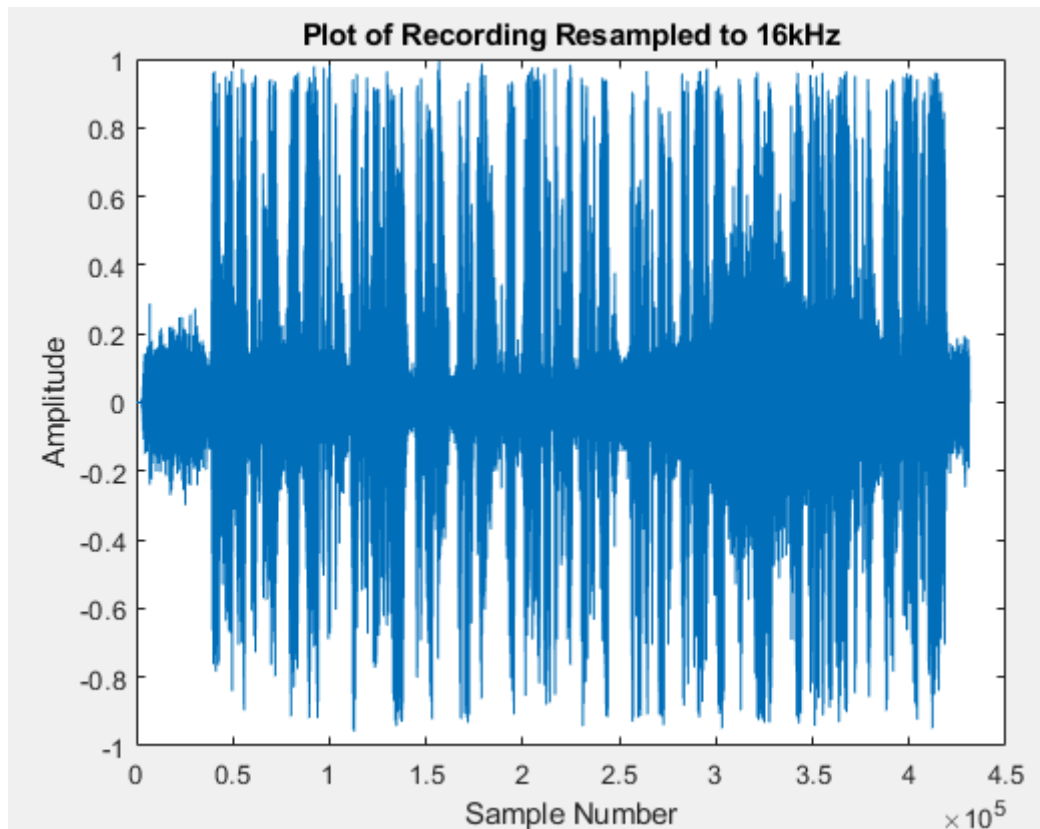
Table 2: Scoring Table

Words identified	___ out of 15 = ___ %
Conversation score	___ out of 5 = ___ %
Total	$\text{___ \%} \times 0.4 \text{ (Weighted Word Percentage)}$ $+ \text{___ \%} \times 0.6 \text{ (Weighted Conversation Percentage)}$
	$= \text{___ \%}$

List of Words for Word Test:

- Fridge
- Waterloo
- Have
- Electricity
- The
- Popcorn
- Water
- Trees
- Fifth
- Today
- Celebrate
- On
- Indigo
- Caterpillar
- Petunia

Question 3.5 graph



Question 3.7 graph

