Real Time Frequency Customizable Voice Synthesis Signal Processor for Cochlear Implants

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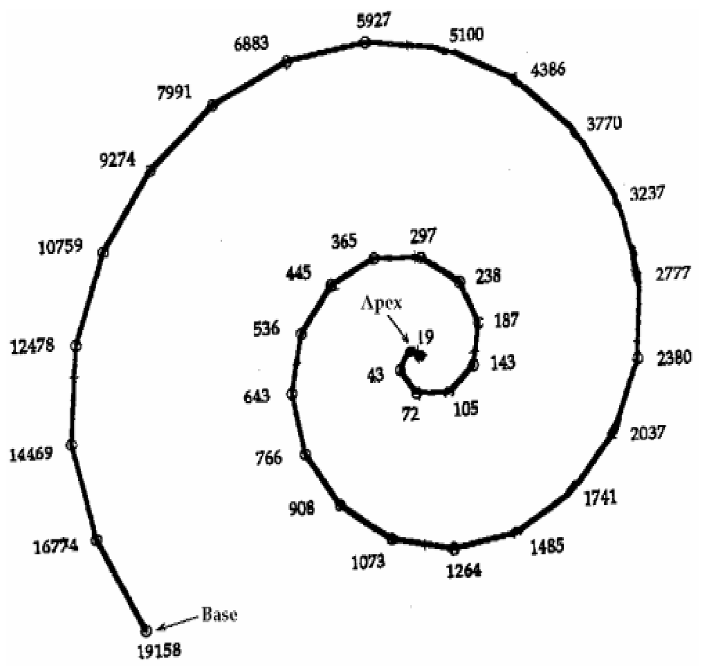
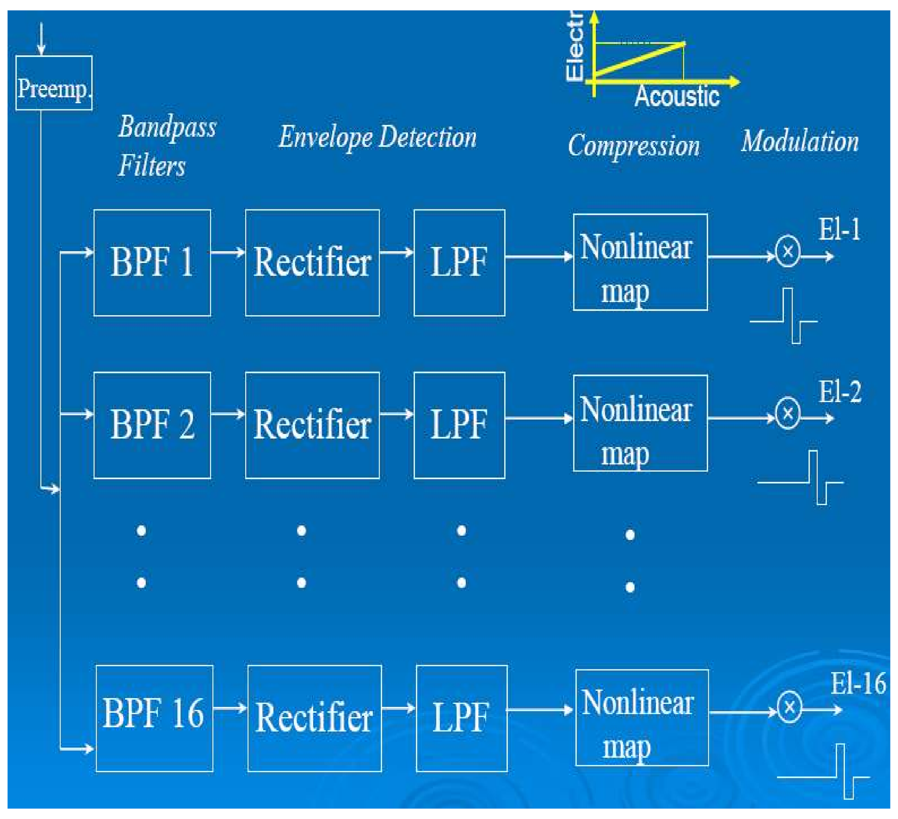
Project Goals:

- Research several different cochlear implant signal processing strategies and implement the best options.
- Design a program to emulate a cochlear implant signal processor utilizing hybrid programming strategies.
- Become familiar and proficient in Labview and Matlab processes and integration techniques.
- Create a synthesized audio signal to emulate what a cochlear implant user might hear.

Project Overview:

Cochlear Implants have 16 to 22 electrodes that are surgically implanted into the cochlea. Each one of these electrodes stimulates a nerve that corresponds to a different perceived frequency, as illustrated in the coiled figure below. By breaking down the received audio signal into separate frequency bands, we can excite the electrodes so that the user will perceive a recognizable sound. The flowchart below demonstrates the signal processing technique.



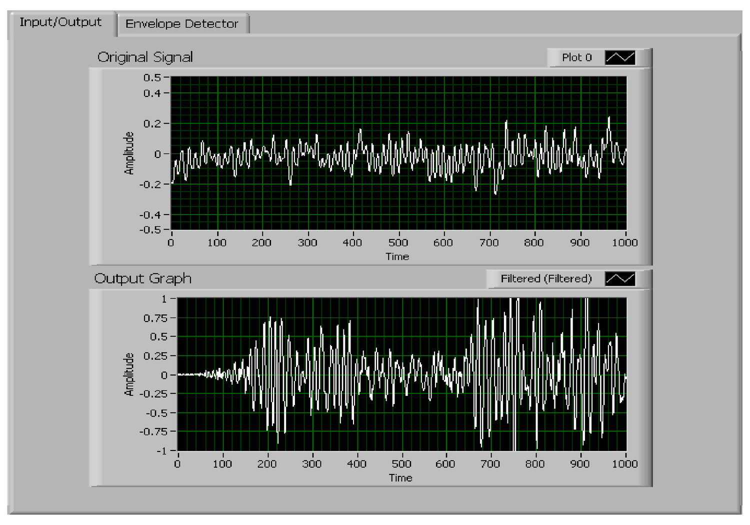


LabVIEW is very powerful software that makes it easy to create, analyze and manage signal processing routines. The built in filters and microphone entry routines make it ideal for this project. The ability to quickly create and edit graphic user interfaces gives us flexibility in our design and allows us to adjust values for optimum performance. Frame size, frequencies, filter types and orders, and synthesis strategies will be easy to monitor and change from a GUI. LabVIEW also integrates seamlessly with many other programs like MATLAB. MATLAB is very efficient in signal processing routines, so we will benefit from using MATLAB blocks for number crunching. This hybrid programming technique allows us to utilize the best features of each programming language. Our final program must run at real time speed for a cochlear implant to properly function, so programming efficiency is crucial.

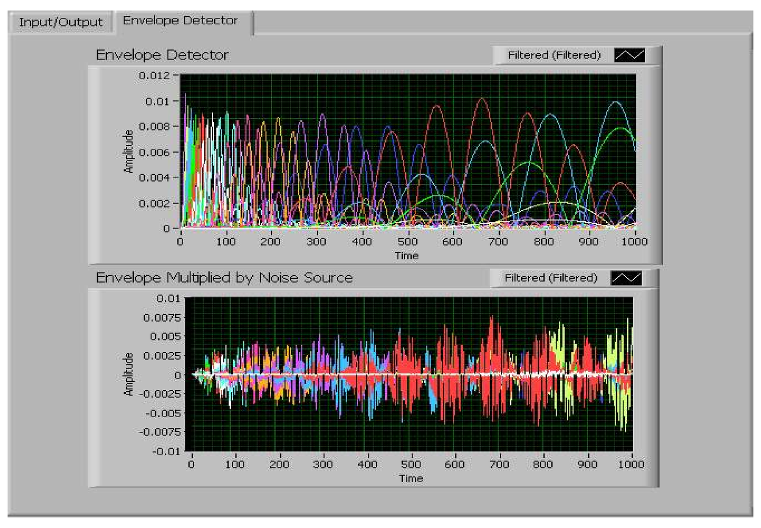
Project Results:

LabView 8.2 Approach:

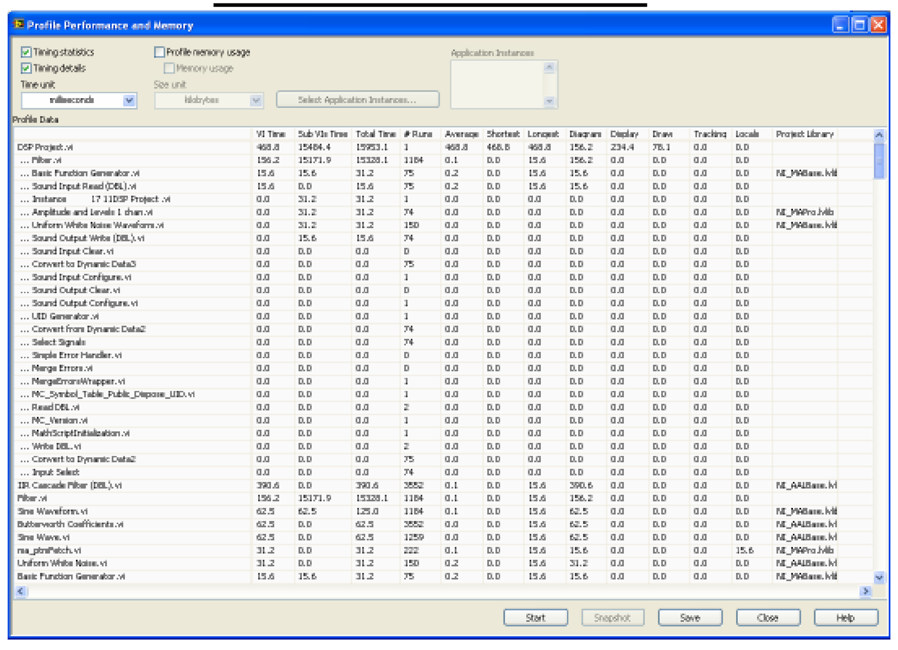
Input/Output



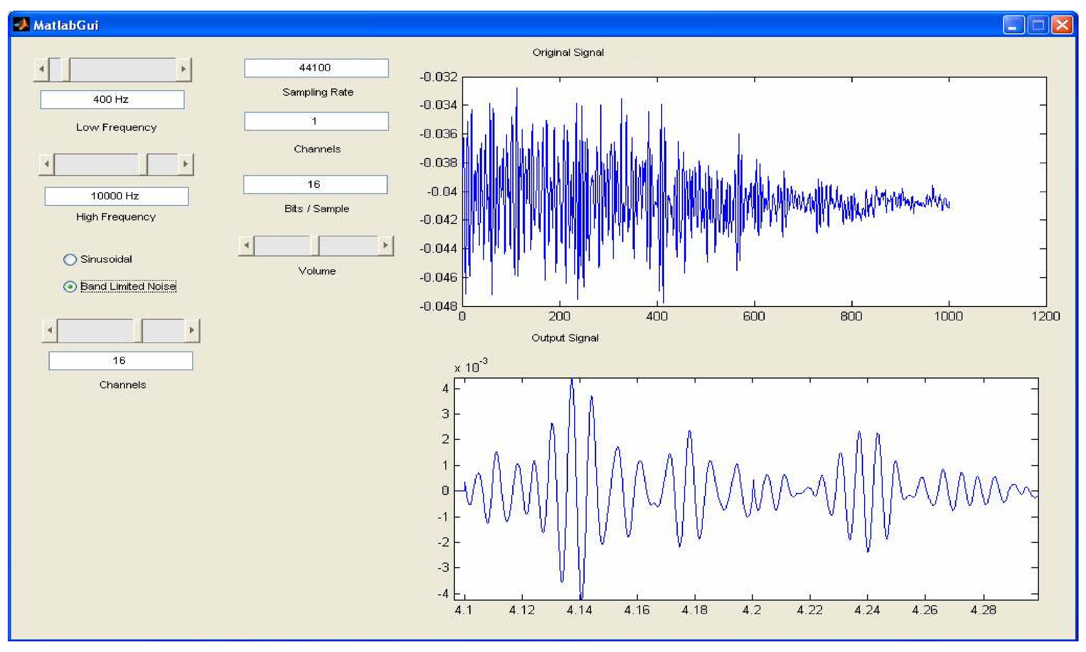
Envelope Detector



Profile Performance



Matlab R2006b Approach:



Project Conclusions/Outcomes:

- Frame size and processor speed are the most important elements in determining how well our program works. The larger the frame size, the larger the delay from input to output. We found that a frame size around 1400 samples is ideal, but only certain processor speeds could reach this value. We have been able to consistently achieve around 2000 samples per frame
- The upper and lower bound frequencies that we select also change program performance. We have found that 200 Hz to 6000 Hz provides optimum performance
- We have implemented a white noise and a sinusoidal voice synthesis technique. We found that the white noise technique outperforms the sinusoidal approach.
- We have tried many filters and filter orders and determined that 6th order butterworth filters work best in our program.