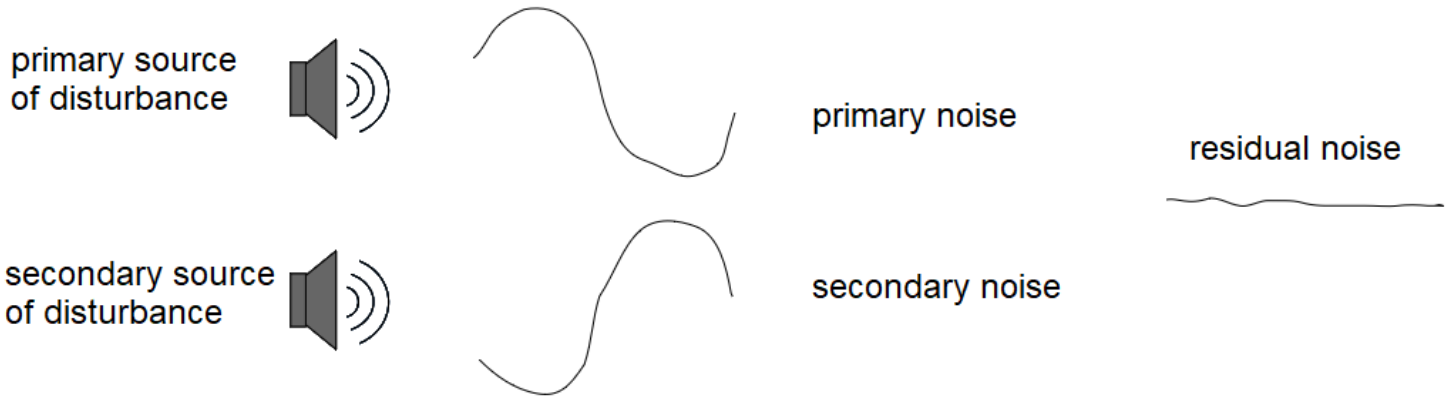
October 2020

APPLICATION OF FREQUENCY-DOMAIN CONTROL ALGORITHMS FOR ACTIVE NOISE REDUCTION SYSTEM

Master Thesis



IDEA OF ACTIVE NOISE CANCELATION

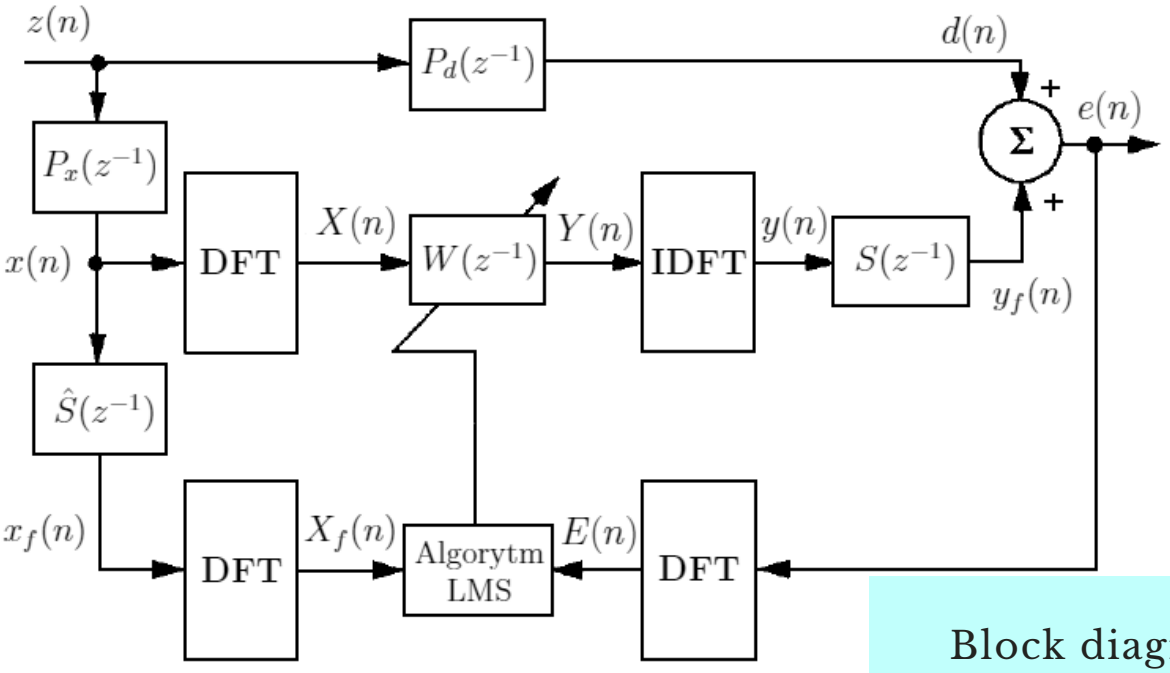
Introduction to the problem

Active noise reduction, also known as ANC for short, aims to remove a significant portion of the unwanted noise from the environment. The idea of ANC is presented in the figure. The signal of the secondary noise source is generated by an electromechanical transducer in the control loudspeaker based on a sampled and processed signal from the electro-acoustic transducer in the microphone.

The generated secondary signal is a 180-degree phase shift representation of the primary signal. Residual noise is created as a result of destructive interference of primary and secondary signals. Its level, i.e. the amount of primary noise elimination, depends on the accuracy of the amplitude and phase of the generated secondary signal. These signals are processed in the DSP circuit.

THE CODES OF THE MASTER THESIS:

https://github.com/MonikaTargosz/GraduateWorkANC



Block diagram of the FXLMS algorithm in the frequency domain in an active noise reduction control system

APPLICATION

Specification:

Program for simulating a single-channel active noise reduction system with forward feedback for the purposes of research. The program enables the analysis of the system convergence for the frequency and time implementation of the FxLMS and LMS algorithms. The diagram of the selected algorithm is shown in figure.

The returned results for the user are: calculated indicators, operating time of the algorithm performed after each switching of the error microphone, characteristics graphs, graphs of the waveforms of the tested indicators, functions and signals.

Programming Technique:
MathWorks MATrix LABoratory environment, object-oriented programming

The program consisted of a main program and a set of classes to simulate the operation of active noise reduction algorithms:

A) class modeling the operation of the active noise reduction, including the operation of the disturbance and secondary paths, and different modes of operation of the algorithm (LMS and FxLMS),
B) class modeling the operation of the adaptation algorithm implemented in the time domain,
C) class that models the operation of the adaptation algorithm implemented in the frequency domain.

A GUI was created to collect user data and present the results.Working with the simulation program consists in entering the simulation parameters in the displaying windows.

Concern: The implementation of ANC algorithms in the frequency domain requires operating on spectral signal forms obtained from the Fourier transform. The DFT (Discrete Fourier Transform) and FFT (Fast Fourier Transform) algorithms are characterized by high computational complexity, which limits the possibilities of their application, significantly increasing the data processing time while increasing size of the control filter. The solution assumed a block implementation of the tested algorithms, consisting in buffering the input and output samples and computing the transform in a sliding window. However, this method introduced additional delays in the signal processing circuit, which introduced slow convergence.For this reason, a new solution was proposed and the recursive algorithm SDFT (Sliding Discrete Fourier Transform) was used. The advantage of the applied approach was the breakdown of the calculations into small operations, repeated every sampling period, instead of a long computational process, possible only after collecting all the data, updating the transform value with new samples, requiring only 4 multiplication operations and 4 addition operations per single transform element.