Development of a Digital Sound Level meter for statistical Analysis of Impact Noise From Manufacturing Facilities

ME1097 Special Projects Proposal

Professor:
Student:
Term:

Background:

The National Institute of Occupational Safety and Health (NIOSH) is in the process of conducting hearing conservation studies involving impact and impulsive noise sources. Currently, data have been collected in the form of digitized sound pressure measurements for various jobs at a stamping facility. It is desired to produce new metrics to predict hearing loss since current integrated metrics (e.g. Leq, TWA, etc.) do not correlate well to hearing loss in impulsive/impact type noise environments. Evaluating the data will require that signal processing tools be developed in MATLAB, including the rudimentary elements of a sound level meter. The primary product of this study will be the set of MATLAB analysis tools for broadband pressure signal measurements and a report on the development of the tools. Topics that will be learned include:

1. Analog signal processing (e.g. RMS values, detector circuits, Leq, noise dose, and other integrated metrics)
2. Digital signal processing (using finite and infinite impulse response filters)
3. Knowledge of ANSI standards S1.4, S1.11, S1.43, S1.25 which govern sound level meters, noise dosimeters, and their filter networks
4. Advanced MATLAB programming, including GUIs
5. Post processing of raw acoustics data
6. Use of an SLM and of signal analysis equipment

Most of the background references will be supplied by the professor.

Statement of Work:

1.1 Develop MATLAB Sound Level Meter

Create MATLAB code that will simulate the device shown in Figure 1. The following capabilities should be included:

1. Develop provision to add calibration factor (scale the data)
2. Develop weighting networks for flat, A, and C weightings by developing a digital filters which meet the ANSI specifications S1.4-1986
3. Develop Weighted and unweighted peak Measurement
4. Allow the tolerance to be changed between Type 0, 1, and 2 instrument specifications (ANSI S1.4-1986)

5. Develop RMS circuit with exponential averaging (detector circuit) with variable time constant, including impulse (35 ms), fast (125 ms), and slow (1s) time constants.
6. Develop SLM computations for Lavg, Leq, TWA, and dose
7. Develop a provision (flag) to display the time history of the waveform
8. Develop 1/3-octave and 1/1-octave band digital filters which meet the ANSI standard S1.11-1996
9. Develop a provision to display 1/1- or 1/3-octave bands or autospectral density (FFT) or spectograms.
10. Add the capability to compute the following nonstandard SLM measures (maybe click a box and additional features appears in the menu).

    Operations on unfiltered and undetected input:

    1. Number of positive samples
    2. Number of negative samples
    3. Time duration of the sample
    4. Inverse of time duration (Hz)

    Operations on filtered and detected input:

    5. RMS level (just Leq)
    6. Peak, rise, and fall times
    7. kurtosis (fourth central moment of pressure divided by fourth power of standard dev.)
    8. Impulsive (peak pressure/RMS pressure)
    9. Crest Factor = $20*\log_{10}$(Impulsive)
    10. Index of impulsiveness/peakedness $(\text{kurtosis/Impulsive})^2$
11. The code should be easily expandable to add new metrics on the filtered, detected signals.
12. Develop a nice menuing system with the MATLAB graphical user interface (GUI) that will allow the user to load files in .mat, ASCII, or .wav format and use all of the above features.
13. Also create a method of using the SLM code(s) for batch-processing of signals (use as a callable function instead of a stand along program with the GUI controls)

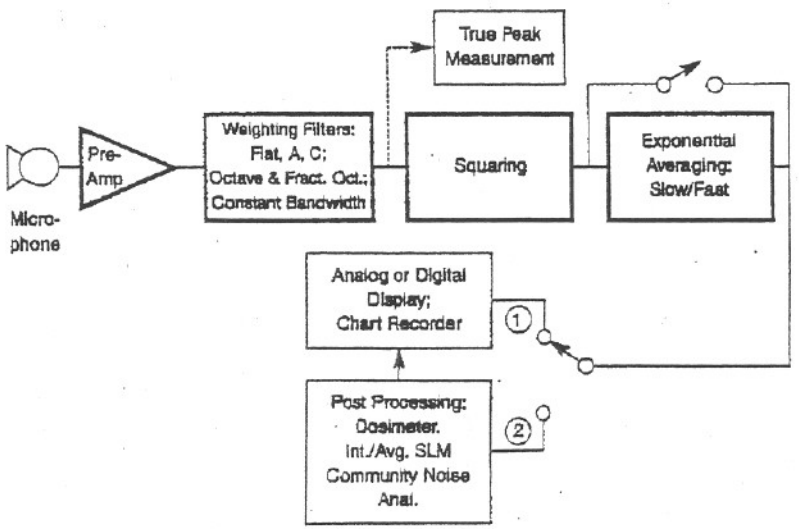

Figure 3.1 — Generic sound level analyzers (blocks shown with bold borders represent basic sound level meter components).

1.2 Test the system against the departmental SLM

Record various types of sounds in the laboratory (impulsive, continuous, broadband, single and multiple frequencies) with the National Instruments system or the Siglab analyzer so that they can be post processed with the MATLAB SLM. Also simultaneously measure the signals with the departmental SLM to verify operation of the MATLAB code.

1.3 Process NIOSH Signals

A total of 410 .wav files will be batch processed in order to determine the utility of the data for hearing loss predictions. The data will be batch processed using MATLAB, which will save numeric results and figures as necessary.

1.4 Write a user manual for the digital SLM and document the design and testing

1.5 Provide Report summarizing the review and analysis of data samples

This report will summarize the development of the MATLAB algorithms and detail the results of processing the signals. As mentioned in each of these subtasks, the report will specifically address the completeness of the data and sampling methods, the adequacy of the instruments and digitization methods, and sources of error and variability in the noise. A draft report will be submitted for review by NIOSH personnel, followed by a final report after any required revisions.

Timeline:

The scope of work is intended working 5-6 hours per week for 14 weeks, which is commensurate with a 3 credit hour course.

Task:	Jan	Feb	Mar	Apr
Develop guts of SLM in MATLAB	x	x		
Test the MATLAB computation code	x	x		
Develop GUI and Batch Processing Part		x	x	
Develop User Manual			x	
Analyze Wavelet Data			x	x
Draft Report				x
Final Report				x