EE232 Signals & Systems

Final Project

Issue Date: 20th May 2021 **Due Date:** 17 June 2021

DTMF ENCODER & DECODER

When we touch a touch-tone pad of Telephone it generates signals in the form of dual tone multiple frequency (DTMF) in order to dial a telephone. When any number is dialed and the key is pressed, s sinusoidal waves of the corresponding row and column frequencies are generated and summed together. The frequencies for each number are given in the table. For instance, if a 3 key is pressed, signal is generated containing the sum of the two frequencies/tones, 697 Hz and 1477 Hz. The frequencies for each digit are chosen by design engineers to avoid harmonics. The sum and difference between any two frequencies does not come equal to any of the given frequency and no frequency is an integer multiple of another. This allows to detect the tones in the dialed signal easily even in the presence of non-linear line distortions.

Frequencies	1209 Hz	1336 Hz	1477 Hz
697 Hz	1	2	3
770 Hz	4	5	6
852 Hz	7	8	9
941 Hz	*	0	#

The steps involved in decoding a DTMF signals are:

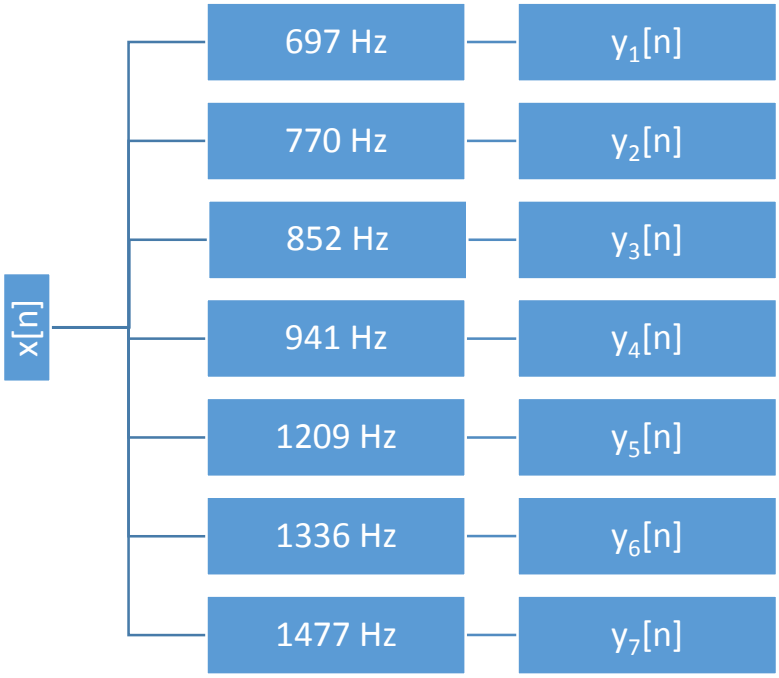
1. Division of the time signal into small segments which represent the individual key presses.
2. Filtering the individual segments for extracting the frequency components. This step is performed using bandpass filter to isolate the sinusoidal components for each frequency.
3. Determining the two frequency components that are present in each time segment. It is done by measuring the size of the output of the bandpass filters.
4. Determining the pressed key, 0-9, * or # by converting the detected frequency pair back into the digit form using the above table.

Process:

The decoding of DTMF signals can be done using a simple FIR filter bank. Figure below shows a filter bank of seven bandpass filters and each filter can pass only one of the seven possible frequencies. The input of the filters is the same DTMF signal. When the input to the filter bank is given as a DTMF signal, the outputs from two of the BPFs should be larger than the rest. The two outputs will be detected to find out the corresponding frequencies. These frequencies can be mapped with the table to determine the key from the DTMF code. A good measure of the output

levels is the peak value at the output of the filter, because a BPF should pass only one sinusoidal signal and the peak value will be the amplitude of the sinusoidal signal passed by the filter.

You have to design a complete system that is capable of DTMF dial tones generation and then decoding them.



Tasks:

1. Write a MATLAB function that takes in a vector "phone_no" and sampling frequency "fs" and returns an appropriate tone sequence corresponding to the dialed number. Take fs=8 kHz and display a spectrogram of the resulting DTMF signal.

Mention the phone number you choose to dial!

2. Design a bandpass filter with a center frequency w, it determines the frequency location of the filter and length L that controls the bandwidth of the filter. As the value of L increases, the bandwidth becomes narrower.
Plot the magnitude of frequency responses for different values of L. Which length L of the bandpass filter is optimum enough? And Why?
Each bandpass filter must have a frequency response with maximum magnitude equal to one.
Hint: Use freqz command.

3. The next task is to perform DTMF Decoding. A decoding system requires two components: a set of band pass filters (BPF) to filter the individual frequency components, and a detector which should determine if the given component is present or not. The detector will allocate a binary of 1s and 0s to output of each BPF and decide which of the frequencies have more possibility to exist in the DTMF tone. The outputs from two of the BPFs will be greater than the rest and detecting

these two frequencies will give the corresponding digit. Write a MATLAB function that performs the above operations.

Hint: The signal is detected by filtering out the input DTMF tone using a BPF of length L, and then outputs with the maximum amplitudes.

4. Decode the digits in another MATLAB function using the information from the previous task. The final output of this function is the list of decoded digits and it should match the phone number that you have used in the Task#1.

Submission Guidelines:

1. Each group should comprise of 3-4 members. Groups with more than 4 members are not acceptable.
2. Submission on LMS should be 1 per group in the form of a zipped folder.
3. The zipped folder should contain the following:
i): MATLAB codes
ii): Report which includes screenshots of results and participation of group members at the end of the report.
5. Evaluation would be done individually on the performance of each group member in the project. The evaluation will include 8-10 minutes presentation per group with each member presenting a part of the work. The presentation will be followed by a viva on the project as well as associated topics from the course. More instructions on the presentation will be given later.