DTMF Detection (May 2020)

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Abstract- This document serves as our answer to the SESSION 3 → DTMF Detection, for any further clarification on the subject debated in this document please send an email to esther.martin.cuartero@estudiantat.upc.edu joel.delgado@estudiantat.upc.edu

The main objective of this lab session is to use the DFT (efficiently implemented through the FFT algorithm) to carry out the DTMF detection, so for detecting two tones in a signalling signal x.

I. Introduction

Dual-tone multi-frequency (DTMF) signalling is a standard in telecommunication systems. In the DTMF scheme a telephone is equipped with a keypad as shown in "Figure 1".

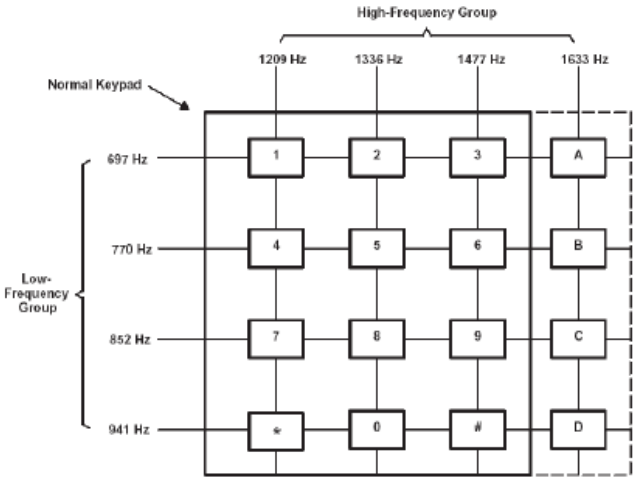

Figure 1. DTMF Keypad

Each key represents the sum of a pair of tones. One tone is from the group between 1 KHz and 2 KHz, and the other one is from the group below 1 KHz. These frequencies are selected carefully so that the DTMF signal, which is the sum of the two tones, can be distinguished clearly as the signalling tone even in the presence of speech waveforms that might occupy the line. In order to reduce the risk of error, tones must be transmitted continuously for a minimum time of about 50ms, with an interdigit pause of a similar duration.

DTMF detection is used to detect DTMF signals in the presence of speech and dialling tone pulses. Besides being used to set up regular calls on a telephone line, DTMF detection is suitable for telephone control features.

II. Procedure for Paper Submission

Along this paper, you will find the code of required function.

First of all, we need to load one of the *.mat* files that we find in Atenea (e.g. choose 24) and we will create a variable "x" to this signal. Now, in order to be able to plot the signal x, we need to know which is the length of the signal x. In our case, "x" has 1024 samples. It's important to remember that, in the function, N need to be higher or equal to "L", in our case N=2^14.

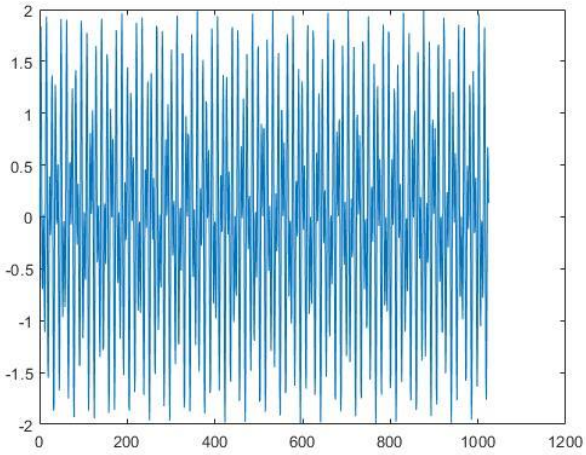

Figure 2. Plot of signal x[n]

The DFT expression is the product of our signal and a window with "a·N" samples**.**

$$X[n] = x[n] \times W[n]$$

$$x[n] = A_1 \times \cos\,(\Omega_1 \times n) + A_2 \times \cos\,(\Omega_2 \times n)$$

$$W[n] = \sum_{k=0}^{a \times N-1} \delta[n-k]$$

So, the final DFT expression of the sinusoidal signal is:

$$X[k] = \sum_{n=0}^{N-1} (A_1 \times \cos(\Omega_1 \times n) + A_2 \times \cos(\Omega_2 \times n)) \times e^{\frac{-j2\pi kn}{aN}}$$

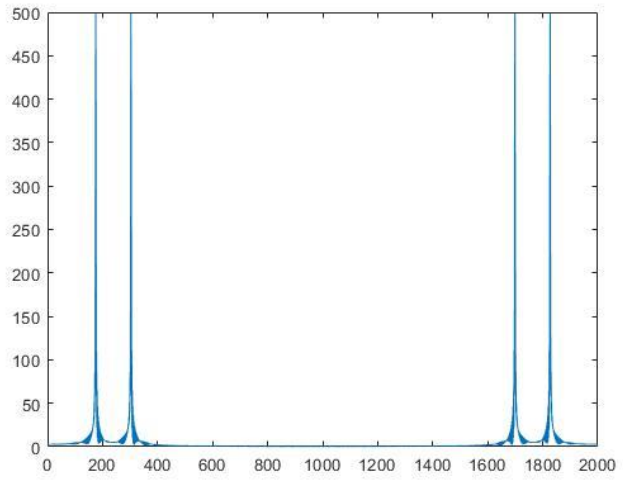

Figure 3. Plot of the signal X[k]

Once we have DFT signal, the function will find a maximum and when is founded, the function will equate to 0 the pos variable to be able to find the next maximum. After that we will obtain the digital frequencies of the two detected tones. As the frequencies are in the discrete domain is needed to convert them into an analogical domain (Hz).

After we obtain the frequencies of the tones, we will be able to figure it out what button of the DFTM Keypad has been pressed. In our case, we select the number 1 button, obtaining 1209 Hz of High Frequency and 697 Hz of Low Frequency. Also, the function gives us the amplitude of the DFT peaks.

III. Units

These are the units we use during the entire lab session:

- "fs" in Hz.

IV. Some Common Mistakes

Here we have some examples of mistakes we had during the lab session:

- Saving the functions in a folder where the program is not capable to find them.
- Not to put "N" as a power of two.
- Not to put "N" bigger than "L".

V. Conclusion

Due to this practice about DTMF (Dual-Tone Multi-Frequency), we have learned how we can obtain the frequencies of two different tones using new functions and commands on MATLAB, such as: dft, fft, max, etc.

Also, before doing the lab session, we had to do a background study for a better understanding of the concepts.

In our opinion, it was interesting to carry out all the knowledge we learned doing the background study and all the concepts of the first and second session of MATLAB. Finally, in the development of this practice, we enjoyed to play with the tone signals so, it was a practical mode to learn about the subject.

VI. References

[1] Introduction to MATLAB: *https://atenea.upc.edu/pluginfile.php/3123187/mod_resource/content/3/Background_Study_Introduction_to_MATLAB.pdf*

[2] DTMF Detection: *https://atenea.upc.edu/pluginfile.php/3123193/mod_resource/content/3/PDS%20-%20DTMF_Detection.pdf*

[3] Official web page of MATLAB: *https://es.mathworks.com/help/matlab/getting-started-with-matlab.html*