Mixed Electronics Lab 8
DTMF Decoder

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1 Introduction

In this project students will use their FPGA to display the results of a DTMF Decoder. They will need to defend the design of their tone detector filters, as well as their decoder system in a report.

1.1 Background

Dial tones on a phone are encoded using 2 of 8 distinct frequencies. It is possible to determine what number is being pressed, by analyzing the frequency content of the dial tone. A breakdown of dial tones is shown in Figure 1. From the figure it is apparent that by identifying the low, and the high frequency contained in the tone, the key value can be decoded. For this lab project students are challenged to design a set of filters, to distinguish 3 different numbers. Students will then be required to design any intermediate systems to digitize the output of the filters, in order to decode the digitized outputs on the FPGA, and display the key value.

1.2 Microphones

Audio speakers are very simple components comprised of a coil of wires around a magnet. The field induced by a current through the coiled wire will cause the magnet to physically vibrate, generating a mechanical sound wave. The frequency of the mechanical wave matches the input signal. Conversely, when mechanical waves jostle the magnet, a current is induced in the wires. This current output directly relates to the incident sound wave.

1. Determine the peak to peak voltage limits of your microphone/speaker
2. create a table that describes the performance of the microphone at varying frequencies and distances.
3. Does your system perform the same with square waves, impulses?

1.3 Tone Detection Filters

There are many methods to filter audio signals and isolate present frequencies. For the purpose of this lab students will design analog filters and amplifiers. Students should consider properties of band pass filters, and design 4 filters, centered at the important frequencies. Students should determine the gain at the resonant frequency, and the Q factor of every filter designed.

1. Design and model the behavior of all 4 circuits. .
2. Determine the Q value for each filter.
3. Build each circuit, confirm its frequency response, its Q factor, and the gain of the resonant frequency.

1.4 Digitizing Analog Signals

Use your knowledge of filters and rectifiers to digitize the output of the tone detector filters. The output of this system should be a digital high when the resonant frequency is being played.

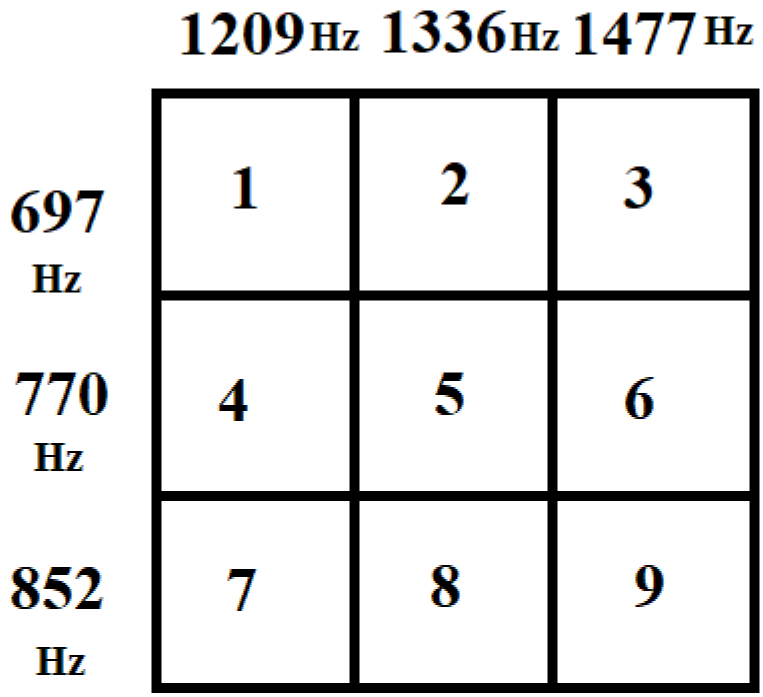

Figure 1: When a key is pressed on a phone two frequencies are played. The key can be distinguished by recognizing which frequencies are being played.

1.5 Digital Decoder

Set up a program that samples the input of all filters frequently enough to respond to a .5 second tone. Develop a system that determines the correct value of the key based on on the output of your filters. Select a method to display your results, and demonstrate the success of your design.

Extra Credit Create a circuit that plays one or more DTMF tones when a button is being pressed. Implement a decoder for all 10 numerical values on a keypad.