**DSP Grad Project**

**Peiguang Wang**

## 1. Problem Description

In homework 11, we are asked to design a polyphase filter bank to implement interpolation. However, in upsampling 32 stage of the polyphase filter, the low-frequency is folded to , where . We apply a low-pass filter (with ) to this signal. When using min-max optimal filter, the ripples have same amplitudes in all stopbands. Since the energy in low-frequency is too large, there will be noise in . In this assignment, we are asked to designed a modified Parks-McClellan filter that the frequency response in are exactly 0.

## 2. Algorithm Proposed

### 2.1 The original Parks-McClellan Revisited

When designing Parks-McClellan Filter, we are using Remez-Exchange algorithm. In Parks-McClellan, since we are using Lagrange Interpolation algorithm, we have:

Equation (1) is derived from Lagrange Interpolations. As long as we are using Lagrange Interpolation, equation (1) is correct.

Since our goal is to satisfy alternation theorem,

Plug (2) into (1) and we have:

### 2.2 Modified Parks-McClellan Algorithm

In this problem, we set frequency response at to 0. By doing this, we will have 16 additional constrains. So we set loose 16 constrains which are nearest to . Let denote the set containing all remaining constrained frequency points in alternation theorem. Let set B denote the set containing frequencies that we want to set the response to 0.

Since we are still using Lagrange Interpolation,

Since and , we have:

Use equation (3) to update in Remez Exchange algorithm and we can get the desired filter.

## 3. Experiment

The algorithm should be as following:

* Using original Remez-Exchange algorithm and obtain the extremal frequency points.
* Find 16 extremal frequencies that are nearest to . Set free the constrains.
* Using Remez-Exchange algorithm with updated in equation (3).

However, due to time limitation, I didn’t successfully implement the filter. The problem I encountered is that in iterations in Remez-Exchange algorithm, there will be discontinuity points in dense frequency set, as shown in figure 1. So there is problem finding L+2 extremal points, there will be much less than L+2 points found.

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Figure 1 Discontinuity in Remez Exchange