Design & Simulation of Surface Acoustic Wave (SAW) Filter at 70MHz for Digital Data Transmission

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Abstract - The Surface Acoustic Wave (SAW) filter has found wide applications in digital communication due to its linear phase response. The important parameters to design SAW filter are number of fingers, spacing between fingers, their shapes. The SAW filter at 70MHz center frequency having bandwidth of 15% will be designed by using 2-IDT structure. The piezoelectric substrate will be used. The proposed filter will show the insertion loss of 2.5 to 3.5dB. The simulation results will be measured using CST microwave studio. By using remez algorithm in MATLAB frequency response is calculated.

Key word - SAW filter, Remez algorithm

I. INTRODUCTION
The uses of the RF devices have been increasing day by day. Filters are the most important device in communication channel. Now a days SAW devices are most commonly used in many systems. As SAW filters have many advantages compare to another filter it has been widely used in many communication systems.

The proposed work will be done to design a SAW filter at 70MHz that can be used for digital data transmission as 70MHz which is called the intermediate frequency for all digital communication devices. By using LiNbO₃ as piezoelectric substrate and 2-IDT structure the SAW filter will be designed. The simulation will be done using CST(Microwave Studio). Also the results in MATLAB are shown using Remez algorithm.

II. DESIGN OF SAW FILTER
Basic design of SAW filter contains IDT structure. Figure 1 shows labeled structure for IDT.

![Fig-1 Labeled structure of IDT](image)

Here P₁ is the pitch of the electrodes, W is the aperture of electrodes and N is the number of finger pairs, h is the thickness of metal line will be deposited on substrate, the width of the finger in IDT and space between IDT will be equal to P₁/4.

SAW Filter Design:–
1. Specifications
2. Selection of Substrate
3. Selection of Metallization
4. IDT Structure

First of all specifications were selected such as center frequency of 70 MHz, Bandwidth as 15% of the center frequency, Insertion loss of 2.5 to 3.5 dB. For the selection of piezoelectric substrate the coupling coefficient, temperature coefficient of delay velocity of SAW waves should be taken into account

Number of finger pairs(n)=\(\frac{1}{BW}\)

Number of finger(N)=2n+1,
value of pitch(\(\lambda\))=\(\frac{\lambda}{2}\)
Width of finger=\(\frac{\lambda}{4}\)

Here the wavelength is dependent on the center frequency and velocity of SAW waves.
Modeling was done using CST microwave studio.

It was giving the appropriate insertion loss but was not able to get sharp cutoff so Remez Algorithm was applied.

### III. Remez Algorithm

The remez algorithm is the method which is used for design of FIR filter. It is also called as Remez exchange algorithm. It was founded in 1934 by Evegeny Vekovlevichl. Remez algorithm uses two methods for designing:

1. The window method
2. The weighted-chebyshev method

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Table 1: Parameters for Design

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Center frequency</td>
<td>70MHz</td>
</tr>
<tr>
<td>2</td>
<td>Wavelength</td>
<td>49.82 µm</td>
</tr>
<tr>
<td>3</td>
<td>Finger pairs</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>Value of pitch</td>
<td>24.91 µm</td>
</tr>
<tr>
<td>5</td>
<td>Width of finger</td>
<td>12.45 µm</td>
</tr>
<tr>
<td>6</td>
<td>IDT length</td>
<td>348 µm</td>
</tr>
<tr>
<td>7</td>
<td>Minimum aperture</td>
<td>70.58 µm</td>
</tr>
<tr>
<td>8</td>
<td>Substrate Length</td>
<td>798 µm</td>
</tr>
<tr>
<td>9</td>
<td>Substrate Width</td>
<td>108 µm</td>
</tr>
</tbody>
</table>

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Flowchart for remez Algorithm

Step-1 For creating this first we need to specify the number of samples, sampling frequency, cutoff frequency, passband ripple and stopband attenuation.

Step-2 After specifying the specifications deviation will be calculated and from that using remez order function number of fingers, aperture and center frequency were calculated, after that using that number of frequency the amplitude or we can say that pattern for IDT can be calculated.

Step-3 By using the fourier transform method the frequency response for that IDT can be obtained.

Step-4 Next the apodization pattern for another IDT will be calculated and same the frequency response for this IDT will be calculated.

Step-5 After that response of both this IDTs were merged and final response will be calculated. By taking 24 fingers for un-apodized IDT calculated the frequency response of unapodizes IDT.
For this pattern fingers were taken having unity overlapping. There is no change in their overlapping. Fingers were assumed to be placed at same spacing and having same width. After that the fourier transform for this IDT was calculated.

As the frequency response is dependent on impulse response here the IDT pattern is in sinc form so got the frequency response as flat. Finally the frequency response of both IDTs were combined and it shows the appropriate response.

IV. CONCLUSION

The function of SAW filter mostly depends on the IDTs such as number of finger pairs in IDT, Spacing between IDT, pattern of IDT (Apodization). By varying number of fingers or even using weighting withdrawal technique we can achieve proper frequency response for any filter.

REFERENCES


