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Variable Bandwidth Filter For Software Defined Radio

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***Abstract*: VDF can be an important block of channelizer for software defined radio. It extracts a desired channel from wideband input. Complexity of a variable digital filter is a concern. A variable digital filter with discrete control over bandwidth is proposed in this paper. The band pass filter response is obtained by combining coefficient decimation II and modified coefficient decimation II. Since both these methods use same set of coefficients except a sign change. Therefore this combination of these two techniques result in less complex systems. VDFs with less complexity can be used in multi standard radios.**

Index terms: Variable Digital Filter, Software Defined Radio, Coefficient Decimation

I. INTRODUCTION

Software defined radio(SDR) which extracts the desired radio channel is a solution for existing and new upcoming standards for wireless communication systems .The concept was first stated by J.Mitola .5G wireless network may have this technology built in it.

Channelizer is supposed to be the computationally complex part of SDR .It selects the required radio channel from the number of inputs channels present. In SDR there is a need of filter/filter banks .Also there is a need of variable digital filter(VDF).Variable digital filter is a circuit in which we can adjust the centre frequency and bandwidth of a digital filter.

VDFs which are proposed earlier are broadly of two types. Those having discrete control over bandwidth and those having continuous control over bandwidth. Though VDFs with continuous control over frequency can give a broad range of bandpass repsonses , VDFs with discrete control over frequency provides a limited range of bandpass responses. The limited set of bandpass response may be useful in selecting certain communication standards from wide band input .To get continuous control over cutoff frequency some techniques used are all pass transformation, fractional delay based structure, frequency transformation based, spectral parameter approximation based.

To get discrete control over cutoff frequency Coefficient decimation approach ,interpolation, frequency response masking based filters are used. Some papers also propose a combination of continuous control and discrete control. In this paper we suggest a method to get a VDF centered around a central frequency 0.5 having discrete control over bandwidth.

II. COEFFICIENT DECIMATION

Coefficient decimation method can be implemented using two types of coefficient decimation .Coefficient decimation I (CDM-I) and coefficient decimation II(CDM II)are discussed in the literature[2].In both the techniques first step is to design a low pass filter called prototype filter .In CDM-I technique decimation is used. A new filter coefficients are derived from prototype filters by keeping M^{th} coefficient and replacing the in between coefficients by zeros. In CDM-I we get frequency bands at even multiples of pi/M. In CDM-II a new filter coefficients are derived from prototype filter by retaining M^{th} coefficients and the in between coefficients are discarded. In this case we get a new low pass filter response with bandwidth M times that of a prototype filter .Modified coefficient decimation I technique resembles the coefficient decimation I technique.Here M^{th} coefficient of a prototype filter is kept and the in between coefficients are made zero and sign of alternate coefficients is reversed. Modified coefficient decimation II technique resembles the coefficient decimation II.Here M^{th} coefficient of a prototype filter is kept and other coefficients are ignored.The sign of alternate samples is reversed.In this technique we get a high pass response with bandwidth M times that of a prototype low pass filter.In [4] band pass response is obtained using MCDM-I and CDM-II we propose a new method using CDM-II and MCDM-II to get a bandpass response. The coefficient decimation method can be represented in tabular form. Assuming that the coefficients of prototype filter are H1,H2,H3,H4,H5,……,HM. Let the value of coefficient decimation factor be 2 .The coefficients selected for coefficient decimation I ,coefficient decimation II, modified coefficient decimation I and modified coefficient decimation II are as shown in Table I.The corresponding values for decimation factor 3 are shown in Table II.

Table I
For M=2

Method	*Coefficients of new filter*
Coefficient Decimation I	*H1,0,H3,0,H5,0,H7……..*
Coefficient Decimation II	*H1,H3,H5,H7……….*
Modified coefficient Decimation I	*-H1,0,H3,0,-H5,0,H7,0,-H9,..*
Modified coefficient Decimation II	*-H1,H3,-H5,H7,-H9,H11,…*

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Table II
For M=3

Method	*Coefficients of new filter*
Coefficient Decimation I	H1,0,0,H4,0,0,H7,0,0,H10, ….
Coefficient Decimation II	H1,H4,H7,H10,…..
Modified coefficient Decimation I	-H1,0,0,H4,0,0,-H7,0,0,H1 0,…
Modified coefficient Decimation II	-H1,H4,-H7,H10,….

III. PROBLEM STATEMENT

In software defined radio VDFs are used to select different communication standard signal depending on requirement .VDF that is proposed in [4] uses a combination of CDM-II and MCDM-I to get variable bandwidth filter. Refer to Table 1 which shows how filter coefficients are selected in various coefficient decimation methods. The VDF proposed in [4] requires a set of multiplexers to insert zeros in MCDM-I and a set of multiplexers to select coefficients depending on value of M .Complexity of VDF is an important factor. In stead of CDM II and MCDM-I if we combine CDM-II and MCDM-II need for MUX-I to insert zeros is eliminated .So complexity of proposed structure will be less. The VDF filter structure proposed in [4] is reproduced here in figure 1.The proposed VDF filter structure is shown in figure 2.

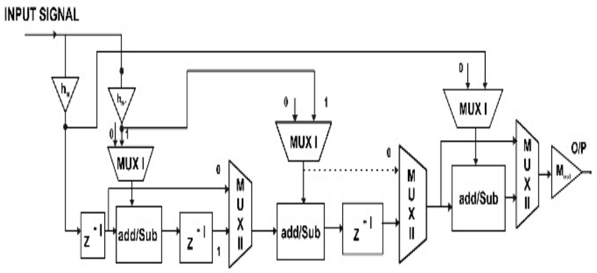

Figure 1 VDF Proposed in [4]

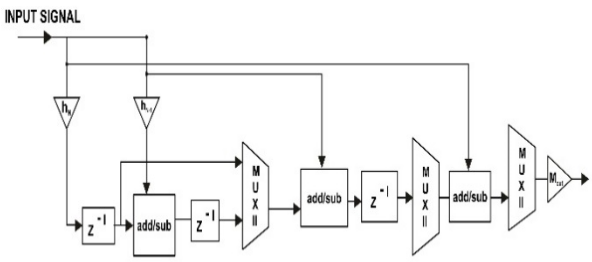

Figure 2 Proposed VDF structure

(1)

IV. SOLUTION APPROACH AND METHODOLOGY

In this paper we suggest a new technique of getting a bandpass response using a cascade of low pass filter and high pass filter .We can get a bank of low pass filters using CDM-II from a prototype filter and a bank of high pass responses using MCDM-II.If we cascade a low pass filter and a high passs filter we can get a bandpass response. As CDM-II and MCDM-II methods have one thing in common that M^{th} coefficient is kept and others are not considered .This combination of two methods CDM-II and MCDM-II can easily be configured in hardware as compared to a combination of CDM-II and MCDM-I.

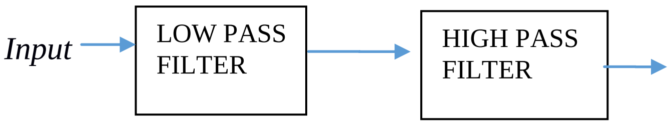

Figure 3 a

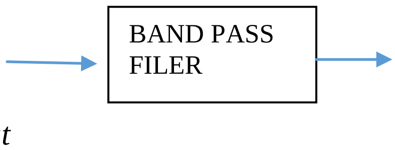

Figure 3 b

Figure 3 a describes the concept of getting a bandpass response. Figure 3 a and 3 b are analogous. A Program is written in MATLAB.A prototype filter is selected as a narrowband filter with specifications Fpass =0.1 and Fstop=0.12.The decimation factor is varied from M=2 to 8 to get low pass responses for seven different values using CDM-II. Figure 4 shows MATLAB output for low pass responses. Also using MCDM-II M is changed from 2 to 8 to get high pass responses. Figure 5 shows MATLAB output for high pass responses. By combining different responses of low pass and high pass we get few bandpass responses around a center frequency of 0.5.The table 3 shows values of decimation factors for CDM-II and MCDM-II and corresponding bandpass response. Figure 4 shows all band pass response. The center frequency for all cases is 0.5.

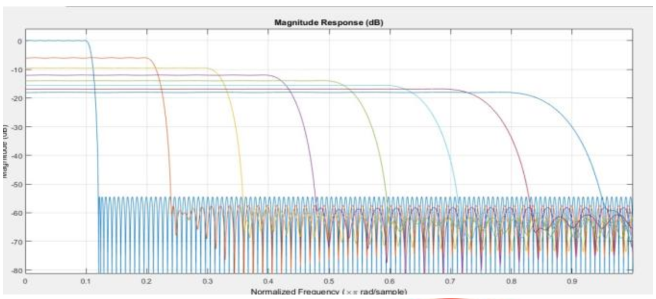

Figure 4 Low pass responses

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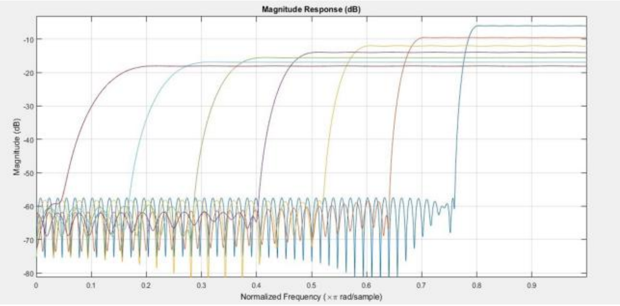

Figure 5 High pass responses

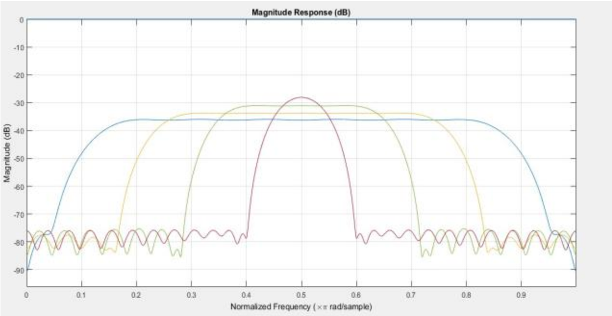

Figure 6 Bandpass responses

Table III Variation in Values of decimation factor

Sr. No.	Values of M for CDM II	Values of M for MCDM-II	Bandpass response with bandwidth
1	8	8	0.8
2	7	7	0.6
3	6	6	0.4
4	5	5	0.2

V. RESULTS AND DISCUSSIONS

The method that is used in this VDF to generate bandpass response is CDM-II and MCDM -II .Since these two methods use the same method of generating coefficients from a prototype filter except a change of sign in alternate coefficients for MCDM II ,this method will be less complex. This is because set of coefficients for low pass filter and high pass filter is the same. In future this VDF can be realized in hardware and can be tested for complexity.

VI. CONCLUSION

VDF proposed in this paper has one center frequency and four bandwidths .But it is limited to only one center frequency technique can be combined with farrow structures to have continuous control over bandwidth. Also it can be implemented in hardware to check complexity.

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