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# Implementation of FIR Filter Structure for Audio Application Using Xilinx System Generator

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***Abstract--FIR Filter is very important type of Digital Filters which is a vital element in Digital Signal Processing. In this paper we design FIR Filter structure and implement it for audio application. FIR filter is a type of digital system that filters discrete-time signal and the main signal, main objective performing frequency domain filtering by processing sample data. It is use in various applications like Speech recognition, Speech synthesis, digital audio, Telecommunication, seismic signal processing (noise elimination), and several other areas of signal processing. This FIR Filter is designed with the help of MATLAB SIMULINK (Win_2012) and XILINK System Generator (ISE_Win_14.2).***

***Keywords- FIR filters, MATLAB SIMULINK, XILINX System Generator, Digital Signal Processing, Digital Filter***

## I. INTRODUCTION

In DSP the major hitch for the developers is the designing of the digital filters for receiver processing and to transmit the various amount of data within desired frequency band according to the filter specifications. Digital filters play vital role in DSP, compared with analog filters, they are preferred in numerous applications like data compression, speech processing and image processing[8][4].DSP processors offer high programmability, but the sequential execution nature of their architecture can adversely affect their throughout performance[3].

## II. FINITE IMPULSE RESPONSE (FIR) FILTER

In signal processing, a finite impulse response (FIR) filter is a filter whose impulse response (or response to any finite length input) is of *finite* duration, because it settles to zero in finite time. The impulse response of an Nth-order discrete-time FIR filter (i.e., with a Kronecker delta impulse input) lasts for $N + 1$ samples, and then settles to zero[1]. A Finite impulse response (FIR) filter is a filter structure that can be used to implement almost any sort of frequency response digitally. An FIR filter is usually implemented by using a series of delays, multipliers and adders to create the filter output. Figure 2.1 shows the basic block diagram for an FIR filter of length N.

The delays in operating on prior input samples. The hκ values are the coefficients used for multiplication, so that the output at time n is the summation of all the delayed samples multiplied by the appropriate coefficients.

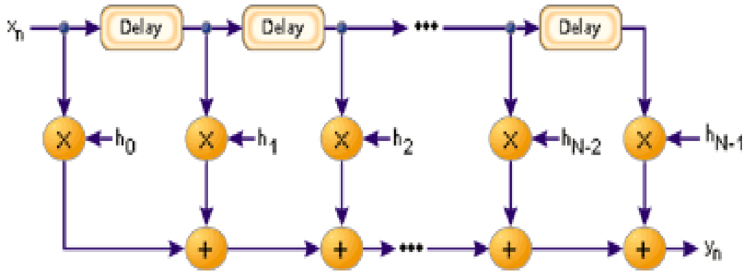


Figure 2.1 Block diagram of FIR filter

The processer selecting the filters length and coefficients is called as filter design. The goal is to set those parameters such that certain desired stop band and pass band parameters will result from running the filter. Most engineers utilize a program such as MATLAB to do there filter design. But whatever tool is used, the results of the design effort should be the same.

$$Y[n] = \sum_{k=0}^{N-1} h(k)\, x(n-k) \quad \text{.....1.2}$$

## III. FIR FILTER DESIGN STEPS

(1) Filter specification: this may include stating the type of filter ex. Low pass filter, desired amplitude or phase responses and the tolerance (if any), we are prepared to accept, the sampling frequency and the word length to input data.

 

(2) Coefficient calculation: at this step, we determine the coefficients of the transfer function H(z) which will satisfy the specifications given in (1). Our choice of coefficient calculation method will be influenced by the several factors, the most important of which are the critical requirement in step (1).
(3) Realization: This involves the converting the transfer functions obtained in (1) into a suitable filter network or structure.
(4) Analysis of finite word length effects: Here, we analyze the effect of quantizing the filter coefficients and the input data as well as the effect of carrying out the filtering operation using fixed word lengths on the filter performance.
(5) Implementation: This involves the production of the software code and/ or hardware and performing the actual filtering.

## IV. IMPLEMENTATION OF FIR FILTER

In this, we have implemented the FIR filter using Matlab Simulink and Xilinx System Generator for the audio application. The following figure shows the implemented structure of FIR filter. This Structure is implemented using compiler FIR filter.

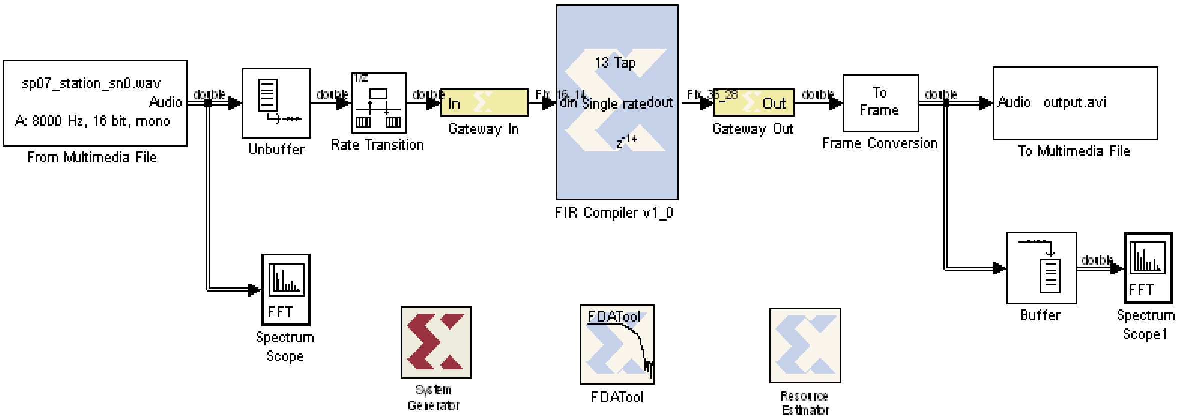


Fig: 4.1 Implemented structure of FIR filter

The input audio signal is selected from the "from Multimedia file" and it is applied on Unbuffer.

### 4.1 UNBUFFER

Unbuffer a frame input to a sequence of scalar outputs. The Unbuffer block unbuffersan $M_i$-by-N frame-based input into a 1-by-N sample-based output. That is, inputs are unbuffered *row-wise* so that each matrix row becomes an independent time-sample in the output. The rate at which the block receives inputs is generally less than the rate at which the block produces outputs.

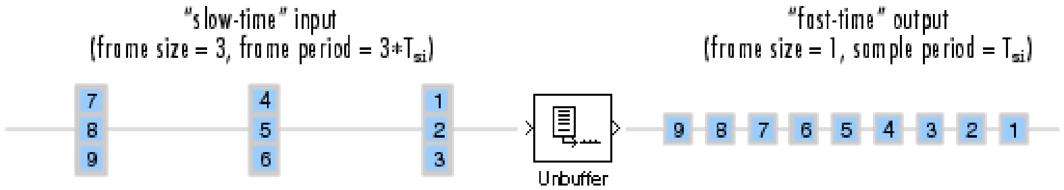


Fig. 4.1.1: Basic principle of Unbuffer

### 4.2 GATEWAY IN

The Xilinx Gateway In blocks are the inputs into the Xilinx portion of your Simulink design. These blocks convert Simulink integer, double and fixed-point data types into the System Generator fixed-point type. Each block defines a top-level input port in the HDL design generated by System Generator.

### 4.3 GATEWAY OUT

Xilinx Gateway Out blocks are the outputs from the Xilinx portion of your Simulink design. This block converts the System Generator fixed-point data type into Simulink Double.

### 4.4 FIR COMPILER V1_0

The Xilinx Fir Compiler v1_0 block implements a high speed MAC based FIR filter. It accepts a stream of input data and computes filtered output with a fixed delay, based on the filter configuration.

### 4.5 RATE TRANSITION

It can handle transfer of data between blocks operating at different rates. The Rate Transition block transfers data from the output of a block operating at one rate to the input of a block operating at a different rate. Use the block parameters to trade data integrity and deterministic transfer for faster response or lower memory requirements.

 

### 4.6 SYSTEM GENERATOR

The System Generator block provides control of system and simulation parameters, and is used to invoke the code generator. Every Simulink model containing any element from the Xilinx Blockset must contain at least one System Generator block. Once a System Generator block is added to a model, it is possible to specify how code generation and simulation should be handled.

### 4.7 MATLAB SIMULINK

The design options in MATLAB allow the user to either create a code for designing filters that calls built-in functions, or to design filters in Sptool, a graphical user interface. MATLAB provides all the information necessary for building a hardware replica of the filter designed in software.

Simulink is a data flow graphical programming language tool for modeling, simulating and analyzing multidomain dynamic systems. Its primary interface is a graphical block diagramming tool and a customizable set of block libraries. It offers tight integration with the rest of MATLAB environment and can either drive MATLAB or be scripted from it. Simulink is widely used in control theory and digital signal processing for multidomain simulation and model-based design.

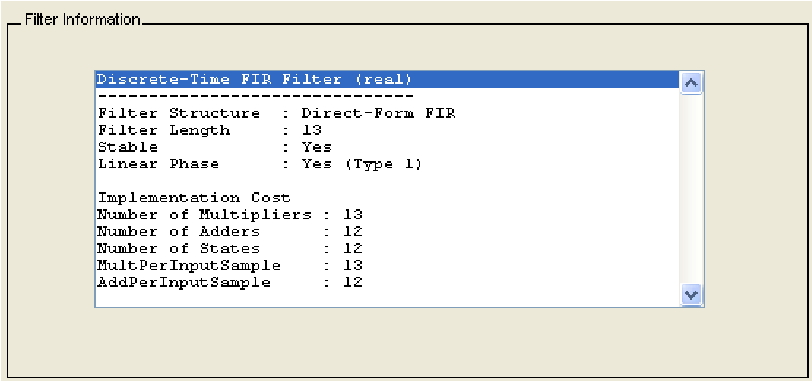


Fig: 4.7.1 FIR filter information

### 4.8 FILTER SPECIFICATION

Table: 1. Filter Specification of 13 tap FIR Filter

| **Filter Specifications** | |
|---|---|
| Order (N) | 12 |
| Structure | Direct form I |
| Response | Low pass filter |
| Design method | Equiripple |
| Pass band Frequency | 4 KHz |
| Stop band | 7 KHz |
| Passband Attenuation | 1 dB |
| Stopband Attenuation | 80 dB |

## V. SIMULATION AND RESULT

The magnitude and frequency response of 12 order FIR filter in which pass band frequency is 4 KHz and stop band frequency is 7 KHz can be observed in fig 5.1. Here attenuation obtain is below 80dB.

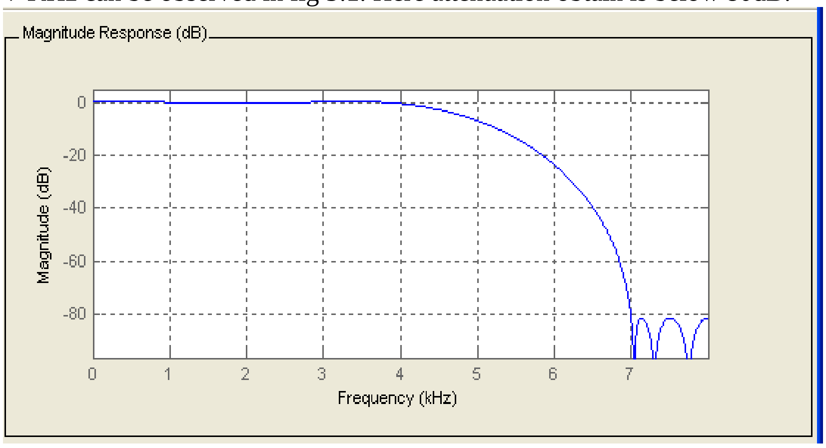


Fig: 5.1 Magnitude response of FIR filter (N=12)

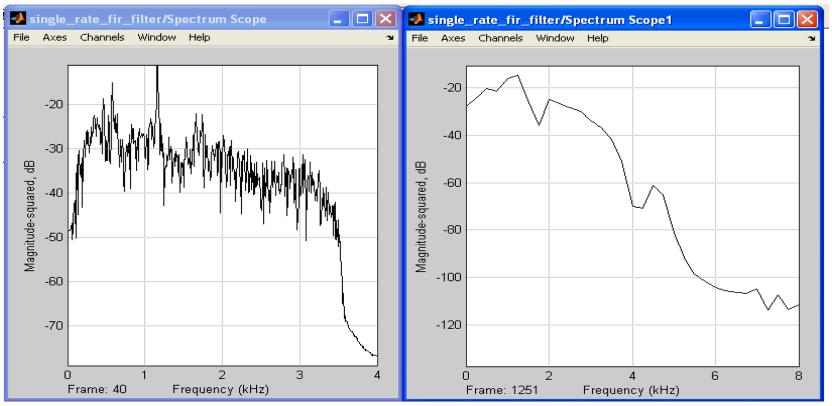


Fig: 5.2 Comparison of input and output signal on spectrum scope

Here we can see the difference between input and output signal of Audio signal. In input Audio signal the noise is more and this noise is reduced in output signal and we got noise free sound.

## VI. CONCLUSION

This FIR filter is implemented using Matlab Simulink model and Xilinx System Generator for selected audio application. The input audio signal of 8000 Hz which is noisy signal with SNR is 0 dB and it is filtered using FIR compiler block which is designed using FDA tool according to the sampling rate, passband frequency, stopband frequency, attenuations, transition width and filter orders and finally we got noiseless signal. The proposed FIR filter structure is verified using Xilinx system generator model and their performances are verified in terms of noise cancellation.

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