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RESPONSE OF DIFFERENT PULSE SHAPING FILTERS INCORPORATING IN DIGITAL COMMUNICATION SYSTEM UNDER AWGN CHANNEL

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ABSTRACT

Pulse shaping process change the waveform of transmitted signal pulses and is mainly used to limit the effective bandwidth of transmission. The inter-symbol interference (ISI) is reduced when we incorporate pulse shaping filter in communication system. In this paper the overview, design and response of various pulse shaping filters is given. The filters like Raised cosine, FIR Nyquist, and FIR and IIR half band with down sampler and corresponding matched filter are used for response. We Plot the magnitude response of these filters under AWGN channel.

Keywords: Pulse shape filter, ISI, ICI, AWGN.

I. INTRODUCTION

Pulse shaping filters are widely used in many modern data transmission systems (e.g. mobile phones, HDTV). The purpose of pulse shaping filter is to keep a signal in an allotted bandwidth, maximize its data transmission rate and minimize transmission errors. The pulse shaping filter has two properties [1]: a) A high stop band attenuation to reduce the inter-channel interference as much as possible b) Minimized inter-symbol interferences (ISI) to achieve a bit error rate as low as possible.

Time domain 'sinc' pulse meets these requirements as its frequency response is a brick wall but this filter is not realizable. We can however approximate it by sampling the impulse response of the ideal continuous filter. The sampling rate must be at least twice the symbol rate of the message to transmit. That is, the filter must interpolate the data by at least a factor of two and often more to simplify the analog circuitry [2].

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Transmitting a signal at high modulation rate through a band-limited channel can create inter-symbol interference (ISI). As the modulation rate increases, the signal's bandwidth increases and when it becomes larger than the channel bandwidth, the channel starts to introduce distortion to the signal generally called ISI. The signal's spectrum is changed and determined by the pulse shaping filter at transmitter. Generally, the transmitted symbols/signals are represented as a time sequence of Dirac delta pulses. This signal is then filtered with the pulse shaping filter, producing the transmitted signal.

In most of the base band communication techniques, the pulse shaping filter is implicitly a boxcar filter. Its spectrum is of the form *sin(x) / x*, and has significant signal power at frequencies higher than symbol rate. This is not a big issue when optical channel or even twisted pair channel is used but in RF systems, this would waste bandwidth. In other words, the channel for the signal is band-limited and hence better filters have been developed, which attempt to minimize the bandwidth needed for a certain symbol rate [3].

In simplest configuration, a pulse shaping interpolator at the transmitter is associated with a simple down-sampler at the receiver.

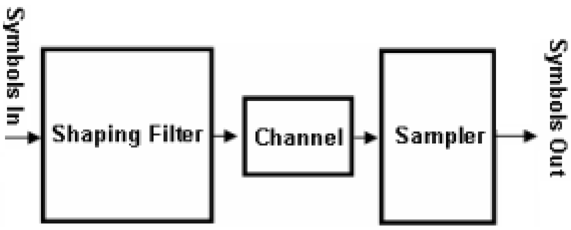

Figure 1: Pulse Shaping Structure.

II. PULSE SHAPING FILTER DESIGN

There is variety of pulse shaped filter available. The design of these filter and their application are different. The various filters are classified as [4]:

- **RAISED COSINE FILTER DESIGN**

A raised cosine filter is typically used to shape and over-sample a symbol stream before modulation/transmission. The roll off factor 'R', determines the width of the transition band. Usually communication systems use a roll-off factor between 0.1 and 0.5. A minimum stop-band attenuation of 60 to 80 dB is also desirable to suppress inter-channel interference. Raised-cosine filter design is obtained by truncating the analytical impulse response and it is not optimal in any sense. In fact, a filter-order as high as 272 is necessary to attain a minimum stop-band attenuation of 60 dB.

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- **FIR NYQUIST FILTER DESIGN**

Nyquist filters can replace raised cosine filters for a fraction of the cost because they have an optimal equi-ripple response. The same stop-band attenuation and transition width can be obtained with a much lower order. The magnitude response of this filter and the raised cosine filter above have the same transition width and minimum stop-band attenuation but the filter order of the equi-ripple Nyquist design has been reduced to 106.

- **MULTISTAGE HALFBAND FILTER DESIGN**

An even more efficient design is obtained by cascading 3 half-band filters. The main advantage of multistage over single stage designs is that longer (i.e. more expensive) filters can be operated at lower sample rates while shorter filters are operated at higher sample rates. Half-band filters can be designed using FIR and IIR design techniques.FIR designs have an additional advantage in that every other coefficient is equal to zero. IIR designs can achieve quasi-linear phase and they offer a greater cost savings while achieving extremely low pass-band ripples.

III. USING MATCHED FILTER AT RECIEVER

In this approach, data stream is up-sampled and filtered at the transmitter and then this transmitted signal is filtered and down-sampled by a matched filter at the receiver.

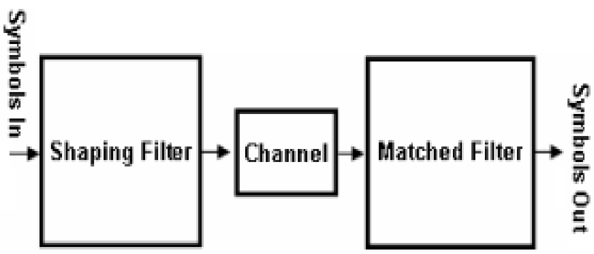

Figure 2: Matched Filter Structure

- **SQRT RAISED COSINE FILTER DESIGN**

In theory, the cascade of two square root raised cosine filters is equivalent to a single normal raised cosine filter. However, the limited impulse response of practical square root raised cosine filters causes a slight difference between the responses of two cascaded square root raised cosine filters and of one raised cosine filter.

- **MINIMUM PHASE FIR HALF-BAND DESIGN**

Minimum phase FIR half-band filters can be substituted for square root raised cosine filters. In such a case, a minimum phase Nyquist filter is used at the transmitter while its maximum phase counterpart is used for filtering at the receiver. The convolution of the minimum phase and maximum phase filters produces a Nyquist filter.

IV. RELATED WORK

Pulse shaping not only reduces inter symbol interference (ISI), but it also reduces adjacent channel interference. The work done by various researchers are: **Dongsong Zeng (2003)** investigated optimal pulse shaping filter that minimizes UWB (ultra wide band) signal interference [5]. **Massimiliano Laddo mada (2003)** described a Digital Pulse shaping FIR filter design with reduced ISI & ICI. The minimization of inter-symbol interference is priority requirement for design of data transmission filters, which is zero if the overall impulse response (transmit filter, channel and receive filter) satisfies the first nyquist criterion [6]. **C. Tan, N C Beaulieu (2004)** has illustrated the transmission properties of conjugate root pulses and its characteristics are compared with the more commonly used raised cosine pulse for three different receiver scenarios [7]. **Nicholas J Bass and DP Taylor (2004)**, investigate the influence of transmit and receive filtering on the design and performance of wireless communication systems. This context was based on derivation to present the pulse shaping filters that can be matched to characteristics of channel by using power series models of time or frequency selective channels [8]. **Pal Orten and Arne Svensson (2004)** have evaluated the performance of DS-CDMA for rectangular pulse shaping and square root raised cosine pulses with different roll off factors. The effects of square root raised cosine chip shaping on BER of a system with or without filter are investigated under additive white gaussian noise (AWGN) channel and Rayleigh fading channel [9]. **Chia Yu Yao (2007)** has proposed a design of SRRC FIR filters by an iterative technique to achieve zero ISI but practically ISI cannot be zero due to some numerical precision problems in the design phase as well as in implementation phase [12]. **Mohd Al Eshtawie (2007)** described that FIR filter has major cons of more hardware requirements, arithmetic operations, area usage, and power consumption when designing and fabricating them. Therefore, minimizing or reducing these parameters, is a major goal or target in digital filter design task for optimum performance [13]. **M.Arif etal (2008)** revealed the design and implementation of IIR filter for wireless communication of an occupied channel so that make transmission distortion free [14]. **M. Renu (2009)** has evaluated BER performance of the system for different fading parameters as well as roll off factor [15].

V. RESULT AND DISCUSSION

The magnitude response of the various pulse shaping filters described below shows minimum stop-band attenuation over 60 dB which reduces the inter-channel interference to satisfactory levels.

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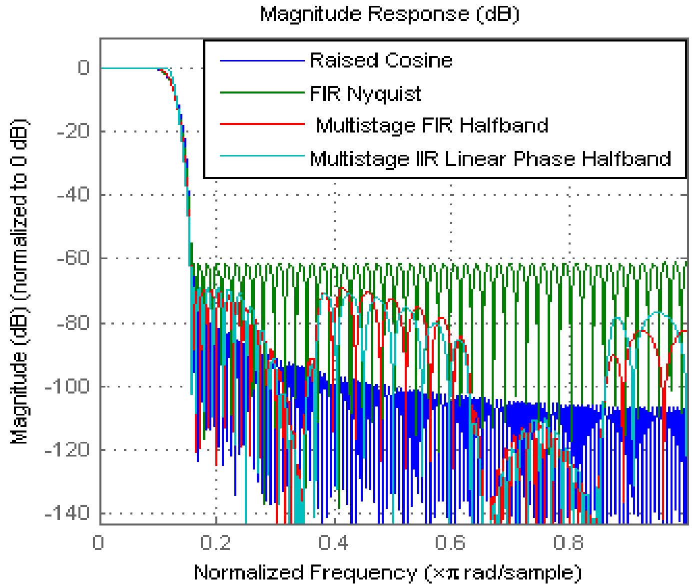

Figure 3: Magnitude Response with stop-band attenuation 60 dB.

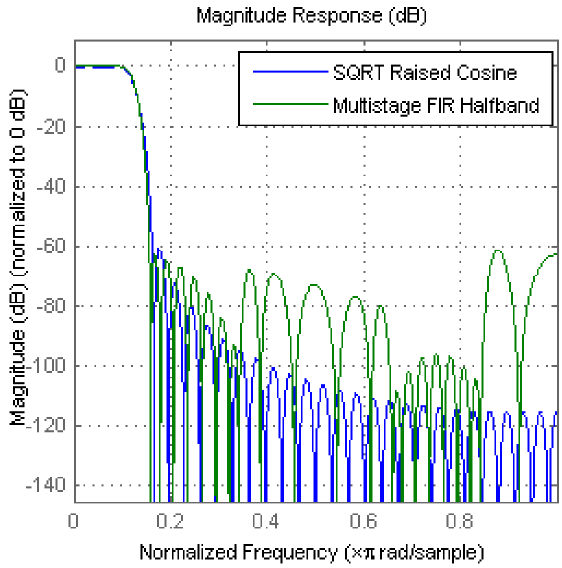

Figure 4: Magnitude response Matched Filters with stop-band attenuation over 60 dB.

Sometimes the filtering is split between the transmitter and receiver. The data stream is up-sampled and filtered at the transmitter and then the transmitted signal is filtered and down-sampled by a matched filter at the receiver. This approach is very popular because, for a given processing power, using two square root raised cosine filters (one at the transmitter and one at the receiver) provides better stop-band attenuation than using a raised cosine filter in the transmitter and a down-sampler in the receiver.

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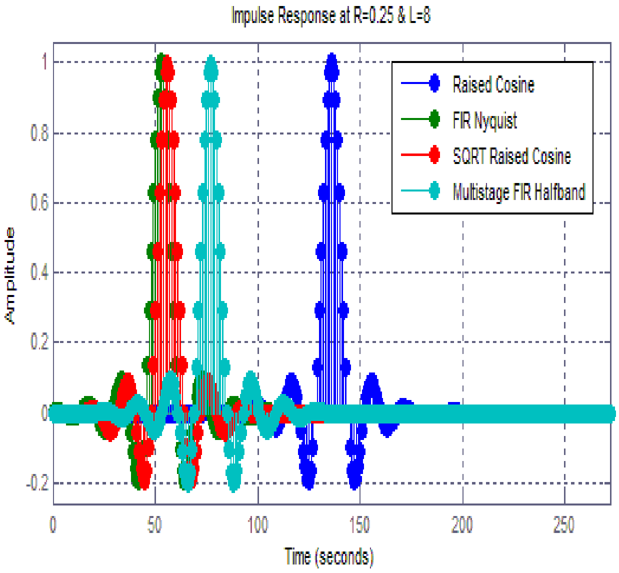

Figure 5.2: Impulse Response of shaping filters

The Complexity evaluations of various filters are given in table 1.

TABLE 1: Complexity of Design of various filters

	Multipliers	Adders
Raised Cosine	274	265
FIR-Nyquist	94	87
FIR-Half band	32	29
IIR-Half band	12	24
SQRT Raised Cosine	114	105
Matched FIR-Half band	56	47

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VI. CONCLUSION

In this paper, we provide the overview, necessity and variety of pulse shaping filters. We verify the magnitude and impulse response of the filter. From the investigation it can be concluded that performance of communication system with pulse shaping filter is better as compared to simple communication system. In complexity in implementation of these filters reveals that IIR Half-band design is simple and less complex and hence less expensive in terms of cost. In second case (matched filter), multistage phase FIR half-band design provides more savings compared to the square root raised cosine design in terms of hardware complexity.

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