Reduction of ISI using RRC filter for Convolution codes with Viterbi Decoding

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Abstract—**The transmission of data over wire and wireless communication system is at high modulation rates through the band limited channel , as the signal bandwidth is more than the channel bandwidth then channel introduces a distortion is called ISI(Inter Symbol Interference) i.e. one symbol is interfere with the another subsequent symbols. This distortion is mainly caused by multipath propagation and non-linearity frequency of the channel. Even in the presence of ISI receiver must be able deliver the data to its destination. To reduce ISI we are using the pulse shaping filter is used at the transmitting and matched filter is used at the receiving end. In this paper the binary data will be pulse shaping can be achieved by RRC (Root Raised Cosine)filter transmitter as well as receive filter which does reduces the ISI and channel noise effects on the pulses transmitted over the band limited channels. Noisy base band symbols are received and first matched filtered using RRC filters ,these filtered symbols are then demodulated and symbol to bit de mapping will be done by 16-QAM (Quad rature Amplitude Modulation)demodulator. Mat lab simulation is performed.**

Index Terms—**RRC filter, ISI, 16-QAM,**

I. INTRODUCTION

In day to day life digital technology ramps up, will involve the transmission of data over one point to another point by increasing the number of R.F applications. These data are modulated by RF carrier such as in cell or mobiles phones T.V and modems, in each case analog data is converted into the digital data like 1's and 0's transmitted by communication mediums in the form of pulses and detected by the receiver. At the receiver to maximize the probability for accurate binary decision can be taken by sampling signal at an optimal point in the pulse duration. i.e. fundamental shape of the pulses does not interfere with the other pulses, such interference called ISI[2][3]. These pulses are not interfere only when the shape of the pulses such that amplitude decays rapidly outside of the interval also zero crossings at the sampling point of all pulse interval. But available bandwidth is limited by data rate and noise in communication systems.

II. INTER SYMBOL INTERFERENCE

Ideally data is transmitted in the form of square pulses, but these pulses are hard to generate and also requires too bandwidth. So the shape of data bits is transmitted in the form of pulses. Let consider the transmitted data is 1, 0, 1, 1, 0,1in rectangular pulses and dotted lines shows the data is in the form of pulses is shown in Fig.1, this data is received through either wire or wireless communication mediums. In this paper data is received through the AWGN channel .Energy from symbols 1and 2 interfere with symbol 3.and reaming symbols interfere with the subsequent symbols is shown Fig.2, the circle area shows the interference is called ISI. This interference occurs due to the non-linearity and charging effects from the frequency selective fading channel[1]. To reduce the ISI slowdown the data symbol and transmit the next data symbol only after allowing, the received symbol has damped down .But time it takes for symbol die down called delay spread

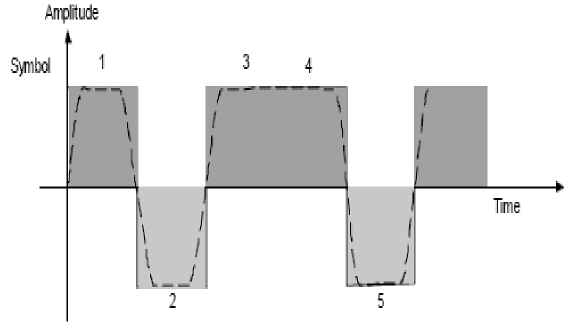

Figure1. Transmitted sequence represented by dashed line.

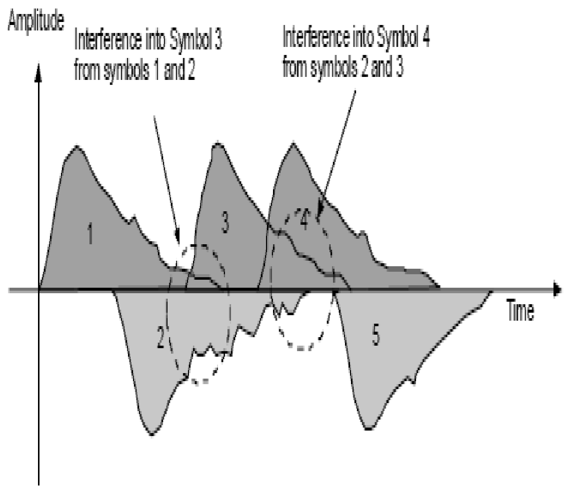

Figure 2. Each symbol in the medium (channel)

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III. PROPOSED SIMULATION METHOD

The proposed simulation model is shown in Fig 3.To control the error transmission input data is encoded by convolution encoder. The modulator generates one symbol for 4-data bits. The symbol generated by the modulator is up sampled and pulse shaped (filtered) to comply with the channel bandwidth restrictions. Typically, the pulse shaping is the last stage of transmitter.RRC filter filters out the signal (i.e., equalizes to give a nearly zero ISI, (if sender is also using RRC filter pulse shaping).The output is sampled at the optimum points (i.e., down-sampled) to give four sample per constellation symbol. The 16-QAM demodulator finds out which quadrant the received sample falls and based on that decision generates a pair of bits.

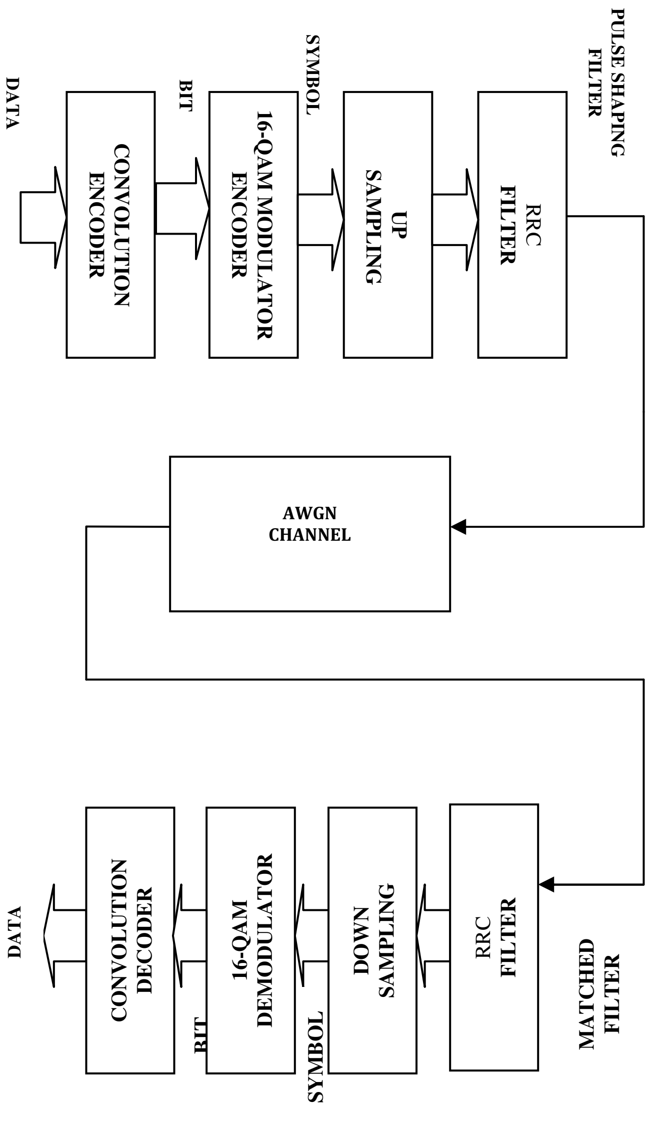

Figure 3.Block diagram of simulation method

The up sampling and down sampling is done at the sending and receiving end, because filters are to be cascaded to obtain a Niquist pulse shape at the output i.e. cascade filters means that no nonlinear operation is allowed between the pulse shaping filter output and matched filter input. To reduce the probability error the matched filter impulse response must be time reversal i.e. H(f)=H(-f).to reduce the ISI the pulse shaping filter response must be zero crossing at multiple of symbol period and sampling rate must be twice the symbol rate. since QAM is not a constant amplitude signaling scheme this leads to bit errors. To avoid this we have to scale the maximum amplitude of the impulse response of the root raised cosine must be oversampling rate is done at the transmitter side. In this paper the design and modification is done to the equation for calculation of the impulse response depending up on the over sampling rate the impulse response thus calculated is used for both pulse shaping at the transmitter and the matched filtering at the receiver.

A. Convolution Encoder

Convolution encoders are popular because they are error detecting and correction codes. To perform this original bit sequence is altered in noise environment communication system. Data bits are encoded either single or multiple bits at a time produces a output based on the generator polynomial. These bits are altered in communication system because of noise and other external factors. To minimize the noise factor, certain additional bits are added to the encoded output which makes the bit error checking more successful and it will also yields more accurate results. This transmission of bits more than the original data bits even in the presence of noise. So that convolutional codes are popular because of these codes are error detecting and correcting codes. Generally these codes are represented by (n, k, m) where n is encoded output sequence ,k number of input bit sequence length and m is the register length.

B.16-QAM modulation

The purpose of modulation in communication system to transmit the data for long distance .in this model encoded bit sequence are modulated by 16-QAM modulator .It converts input bit into 4 symbol mapping in constellation diagram .these symbols are up sampled at the transmitting side and down sampled at the receiver side to obtain the Niquist sample instants .these symbols are shaped by RRC filter and analyzed efficiently over the AWGN channel.

C.AWGN Channel

In communication system, AWGN (Additive White Gaussian Noise) channel introduces most of the noise in real data. It is actually a mathematical model that represents physical phenomena in which the impairment is the linear addition of white noise with a constant spectral density with the distribution of Gaussian form.

D .Viterbi Decoder

The encoded and filter symbols passed through the AWGN channel and received it .At the receiving end these bits are decodes by hard viterbi algorithm. In the decoding process , there are various steps involves they are Quantization, synchronization, branch metric computation, path metric computation and decision making at the output of each state block record each branch and path metric

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values .decoding path is selected which ever path is having less path metric values.

IV.RRC FILTER

In communication system pulse shaping can be achieved by RRC filter to control the ISI, starting and ending portions are attenuated in the symbol period. The width of the pulse sis depends on roll of factor alpha .in this simulation alpha value is used is 0.25and the impulse response is shown in fig.4

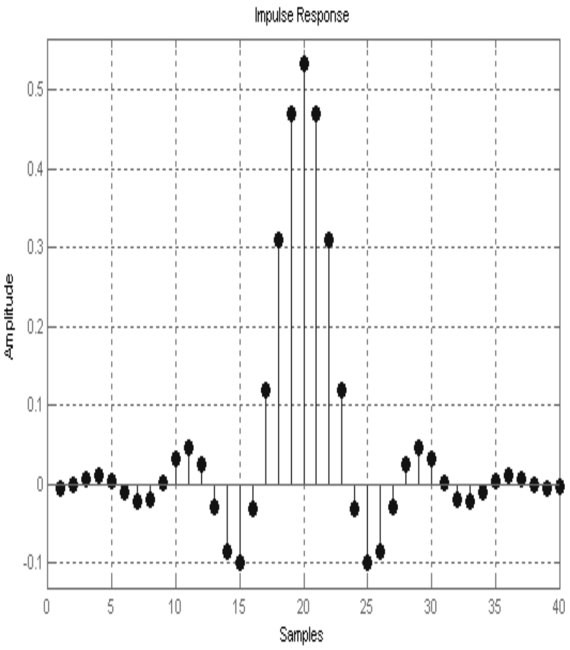

Figure 4: Impulse response of RRC filter.

The response of the filter looks somewhat like square pulse a range of bandwidths are possible depending on the chosen the bandwidth can be anywhere from $1/2R_s$ for the sinc pulse and to Rs for the square pulse.

When the equation becomes pure square pulse. The advantage is that if the transmit side filter is stimulated by an impulse, then they receive side filter is forced to filter an input pulse shape that is identical to its own impulse response, thereby setting up a matched filter and maximizing signal to noise ratio while at the same time minimizing ISI[11].

The transfer function of the RRC filter is

$$H(f) = \begin{cases} 1 & for \;\; |f| \leq \frac{(1-\alpha)}{2T_s} \\ \sqrt{\cos^2 \frac{\pi T_s}{2\alpha}\left[|f| - \frac{(1-\alpha)}{2T_s}\right]} & for \;\; \frac{(1-\alpha)}{2T_s} \leq |f| \leq \frac{(1+\alpha)}{2T_s} \\ 0 & for \;\; |f| > \frac{(1+\alpha)}{2T_s} \end{cases}$$

V. SIMULATION RESULTS

In this paper all the simulations are done using Mat lab.The simulation parameters and their values are shown in Table1.

TABLE I.
SIMULATION TABLE

Parameter	Value
Convolution Code rate	1/2
Modulation scheme	16-QAM
Bit energy to Noise power spectral density, (E_b/N_0)	10 dB
RRC filter order	40
Viterbi Trace back length	32
RRC filter roll of rate	0.25

In this paper the random data is encoded by the convolution encoder with a code rate of ½.theses bits are converted into the symbol of 4-bits long by the 16-QAM modulator. These four symbols are passed through the up sampling then given to the RRC filter order 40 and roll of factor 0.25, these symbols are passed through the AWGN channel it add the nosie 10dB of white noise . in the receiver side these noise is removed by same RRC filter it acts as a matched filter[1] , these filtered symbols are down sample it and demodulate by 16-QAM demodulator and perform the decoding by viterbi .

The proposed method is simulated in Mat lab by the following steps

- Generating a Random Binary Message
- Encoding the Bits is encoded by convolution code of code rate 1/2.
- Bit-to-Symbol Mapping by binary to Gray Code conversion
- Modulate by 16-QAM
- Pulse Shaping Signals Using an FIR RRC
- Adding AWG Noise to the Transmitted Signal
- Filtering Received Signals Using the RRC Filter
- Signal recovery
- Received signal by 16-QAM demodulator
- Bits recover from symbols by gray code to binary conversion
- Decoding by viterbi algorithm.
- Calculate the BER with and without convolution coding.

In digital communication system sending the data in the form of one's and zero's in pulses. Eye diagrams are generated by super imposing two pulses on each other by several times, the generated pattern are looks like human eye. In this paper these diagrams are generated with 4-bit interval of time and repeatedly place for the modulated signals as shown in figure 5. The received signal can be sampled without error can be indicated by eye width. Noise margin and best sample can be taken at the opening of human eye. Actually carrying information is eye amplitude.

These eye patterns are pulse shaped and oversampled a symbol stream before transmission by RRC filter .Practically the pulse shaping RRC filters are windowed. The window length can be controlled by three ways filter order, filter order in symbol durations, and Minimum order to achieve a given stop band attenuation.

In this paper the given proposed design roll off factor is 0.25and up sampling factor is 4 with filter order 40 is shown in figure it compares the data before and after filter.

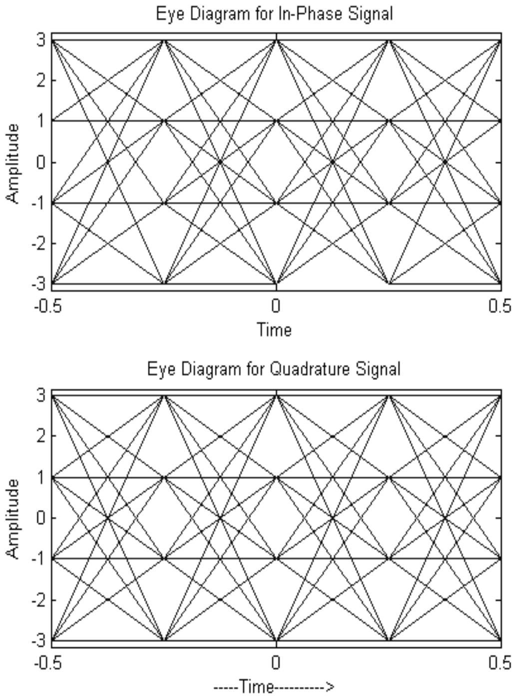

Figure 5: Eye diagram of modulated symbols

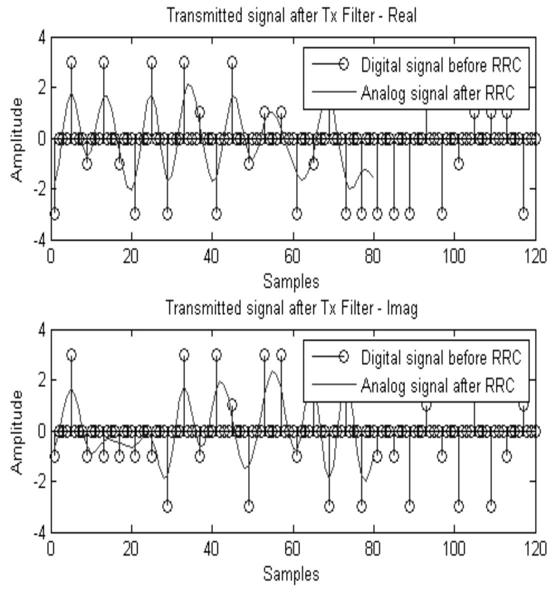

Figure 6: Comparison of modulated signal before and after the filter.

Now the signal is encoded and filtered transmitted through the AWGN channel .it add the additive white noise to the transmitted data .the scatter plot show the transmitted and received signal is shown in figure 7.

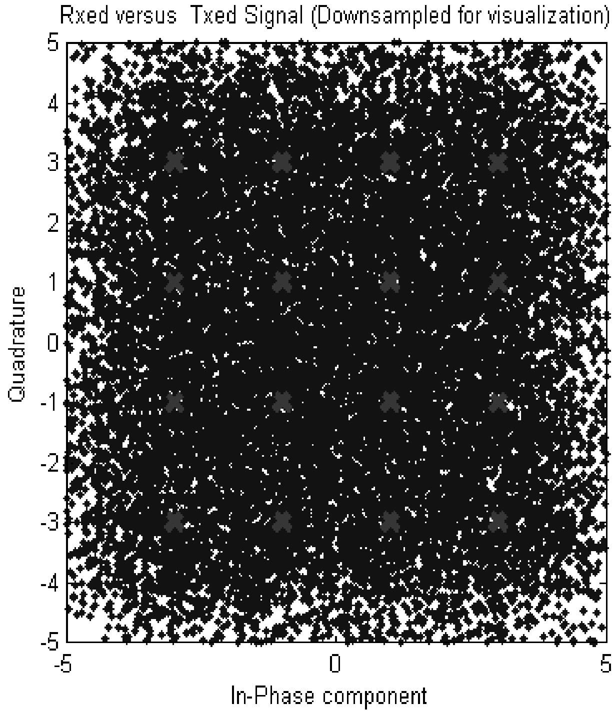

Figure 7: Transmitted and Received signal

Received signal can be recovered from the matched filter by down sample the signal is shown in figure 8 represents the transmitted and received signal after RRC after filtering the signal can be demodulated by 16-QAM demodulator i.e. symbol to bit mapping is done.

These bits are decoded by viterbi decoding.

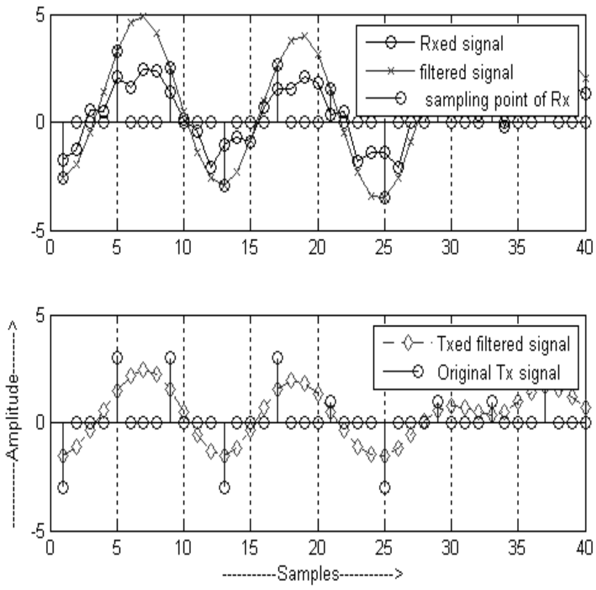

Figure 8: Comparison of signal before and after RRC .

CONCLUSIONS

From the results shown in above prove that ISI and additive white noise can be suppresses for the band limited channels by pulse shaping filters. Also bit error rate is

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reduced by using the convolution encoding and Viterbi decoding of 16-QAM modulator. The application of QAM can be seen in color television to multiplex the chrominance signals, in old telephony systems, in wireless internet modem, power line communication (PLC), digital audio and video broadcasting and wireless ATM transmission system.

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