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Design and Implementation of Optimal Pulse Shaping Filters for Digital Radio Systems

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ABSTRACT: Base band transmission of digital data requires the use of a low pass channel with a bandwidth large enough to accommodate the essential frequency content of the data stream. However the channel is dispersive in that its frequency response deviates from that of an ideal low pass filter. The result of data transmission over such channel is that each received pulse is affected somewhat by adjacent pulses, thereby giving rise to a common form of interference called ISI. To control ISI, control has to be exercised over the pulse shape in the overall system, known as pulse shaping. The mostly used pulse Shaping filters to avoid ISI are Raised Cosine and Root Raised Cosine filters. Another source of bit errors in base band data transmission system is channel noise. Designing a matched filter at the receiver end reduces the additive noise introduced in the channel. Again, widely used matched filters at the receivers are Raised Cosine and Root Raised Cosine filters. All the wireless communication standards like GSM, CDMA etc., use base band pulse shaping over the digital data to reduce ISI and additive noise effects in the wireless channels.

The objective of this design and implement these Raised Cosine and Root Raised Cosine transmit as well as receive filters, which does reduce ISI and channel noise effects on the pulses transmitted over the band limited channels. The digital binary data will be pulse shaped using these filters. The frequency response of these filters decrease towards zero gradually rather than abruptly, which can be realized easily. Then finally using the designed Raised Cosine and Root Raised Cosine filters, a 16 QAM base band communication system over noisy channel will be implemented. Digital data is first mapped into symbols of 16 QAM and then these symbols are pulse shaped and transmitted over noisy channel. Noisy base band symbols are received and first matched filtered using Raised Cosine and Root Raised Cosine filters. Filtered symbols are then demodulated and symbol to bit demapping will be done. Then finally BER (Bit Error Rate) is computed by comparing the transmitted and demodulated bits. MATLAB environment is used for the simulation of proposed algorithm.

Keywords: GSM, 16- QAM, AWGN, BPSK, ISI, CDMA, BER

I . INTRODUCTION

As digital technology ramps up for this century, an ever-increasing number of RF applications will involve the transmission of digital data from one point to another. The general scheme is to convert the data into a suitable base band signal that is then modulated onto an RF carrier. Some pervasive examples include cable modems, mobile phones and high-definition television (HDTV). In each of these cases, analog information is converted into digital form as an ordered set of logical 1's and 0's (bits). The task at hand is to transmit these bits between source and destination, whether by phone line, coaxial cable, optical fiber or free space. The main reason is that the number of bits that must be sent in a given time interval (data rate) is continually increasing. Unfortunately, the data rate is constrained by the bandwidth available for a given application. Furthermore, the presence of noise in a communications system also puts a constraint on the maximum error-free data rate. The relationship between data rate, bandwidth and noise was quantified by Shannon and marked a breakthrough in communications theory.

Before delving into the details of pulse shaping, it is important to understand that pulses are sent by the transmitter and ultimately detected by the receiver in any data transmission system. At the receiver, the goal is to sample the received signal at an optimal point in the pulse interval to maximize the probability of an accurate binary decision. This implies that the fundamental shapes of the pulses be such that they do not interfere with one another at the optimal sampling point.

There are two criteria that ensure noninterference. Criterion one is that the pulse shape exhibits a zero crossing at the sampling point of all pulse intervals except its own. Otherwise, the residual effect of other pulses will introduce errors into the decision making process. Criterion two is that the shape of the pulses be such that the amplitude decays rapidly outside of the pulse interval. This is important because any real system will contain intersymbol interference, which means that the actual sampling point of the receiver will not always be optimal for each and every pulse. So, even if the pulse shape provides a zero crossing at the optimal sampling point of other pulse intervals, intersymbol interference in the receiver could cause the sampling instant to move, thereby missing the zero crossing point. This, too, introduces error into the decision making process. Thus, the quicker a pulse decays outside of its pulse interval, the less likely it is to allow intersymbol interference to introduce errors when sampling adjacent pulses. In addition to the noninterference criteria, there is the ever-present need to limit the pulse bandwidth.

The rectangular pulse, by definition, meets criterion number one because it is zero at all points outside of the present pulse interval. It clearly cannot cause interference during the sampling time of other pulses. The trouble with the rectangular pulse, however, is that it has significant energy over a fairly large bandwidth as indicated by its Fourier transform. In fact, because the spectrum of the pulse is given by the familiar sin $(\Pi x)/\Pi x$(sinc) response, its bandwidth actually extends to infinity. The unbounded frequency response of the rectangular pulse renders it unsuitable for modern transmission systems. This is where pulse shaping filters come into play. If the rectangular pulse is not the best choice for band-limited data transmission, then what pulse shape will limit bandwidth, decay quickly, and provide zero crossings at the pulse sampling times? The raised cosine pulse and root raised cosine pulse, which is used in a wide variety of modern data transmission systems.

2. Implementation of 16-QAM using Root Raised Cosine filter

The implementation of the 16 QAM with root raised cosine filter is similar to the implementation with the raised cosine filter at the transmitter except for some most important differences which arise in the receiver design due to the fact that single Root Raised Cosine filter is a non Nyquist pulse shaping filter and two such filters are to be cascaded to obtain a Nyquist pulse shape at the output. Imposing such a constraint as to cascade the filters means that no non linear operation is allowed between the output of the pulse shaping filter and the input of the matched filter. So sampling and over sampling are not allowed at the receiver before the matched filtering as they are non linear operations so the received base band signal as such has to be given to the matched filter as the input how ever if the impulse response of a single filter in the cascade combination has impulse response normalized to unity the impulse response of the cascade combination of filters will have maximum amplitude more than unity depending on the over sampling rate of the pulse shaping filter. And 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 impulse response depending up on the over sampling rate of the filter such that the impulse response of the cascaded combination of the filters exactly has unit maximum amplitude. In our algorithm design this is done by making modifications 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.

Based on the above considerations the block diagram used for the simulation of 16 QAM with root raised cosine pulse shaping filter is slightly modified from that of the simulation using the raised cosine filter and is as shown in fig.

2.1 Transmitter block diagram:

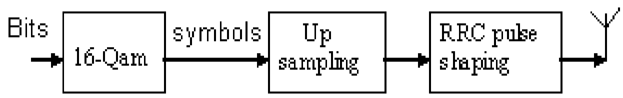

Figure2.1 : Tx block

2.2 Receiver block diagram:

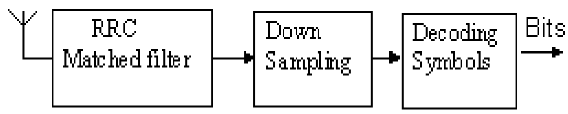

Figure 2.2 : Rx block

The impulse response thus obtained for an oversampling rate of 64 is as shown in the figure 2.3

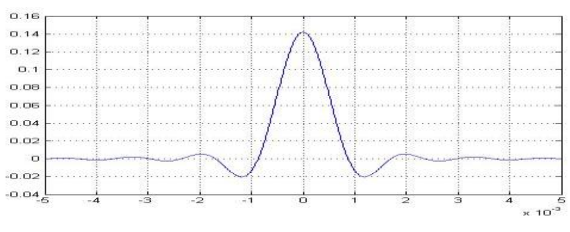

Fig 2.3: **Impulse Response of the Root Raised Cosine Filter**

Now from this figure we can observe two things one is that the non nyquist pulse shape (non-zero at other bit sampling instants) and the other is that the peak amplitude of this impulse response is not unity but is significantly less than unity, this is due to the high oversampling rate adopted for this filter design. The total impulse response of the cascade combination of two such root raised cosine filters is shown below (this is obtained by convolving the individual filter impulse responses):

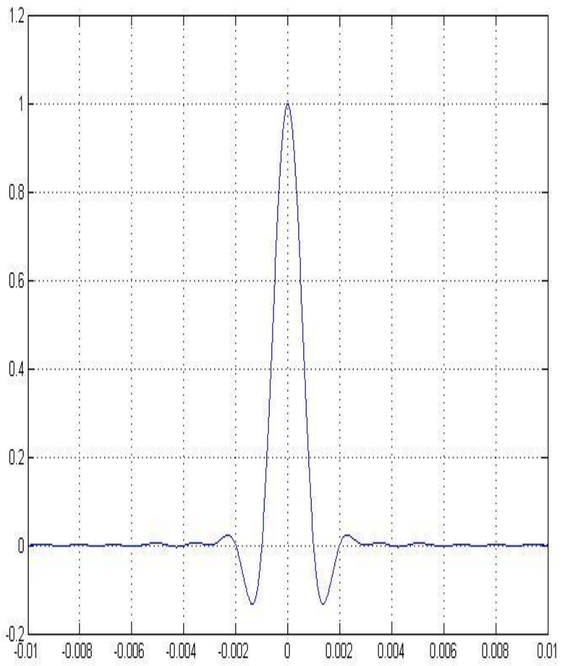

Fig 2.4: **Cascade of two Impulse Responses**

From this figure we can observe that the impulse response becomes zero at the sampling instants of other bits (i.e. ., at +/-0.001s,+/-0.002s…) and the peak amplitude of the combined impulse response is "1" so this does not introduce any amplitude scaling at the receiver and thus results in correct decoding of the received signal.

3. Implementation of Algorithm:

{Bits->symbols->UpSampling->RRCpulseshaping}-> Transmitter ->{AWGN channel} -> channel -> {RRC matched filter ->down sampling->decoded symbols->bits.} Receiver.

4. Simulation results:

Figure4.1: Plot of first 40 random bits

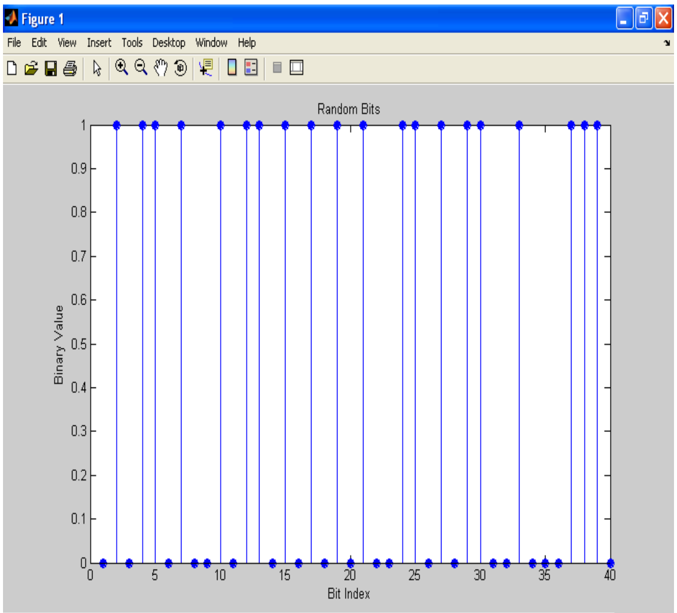

Figure4.2: Plot of first 40 random symbols

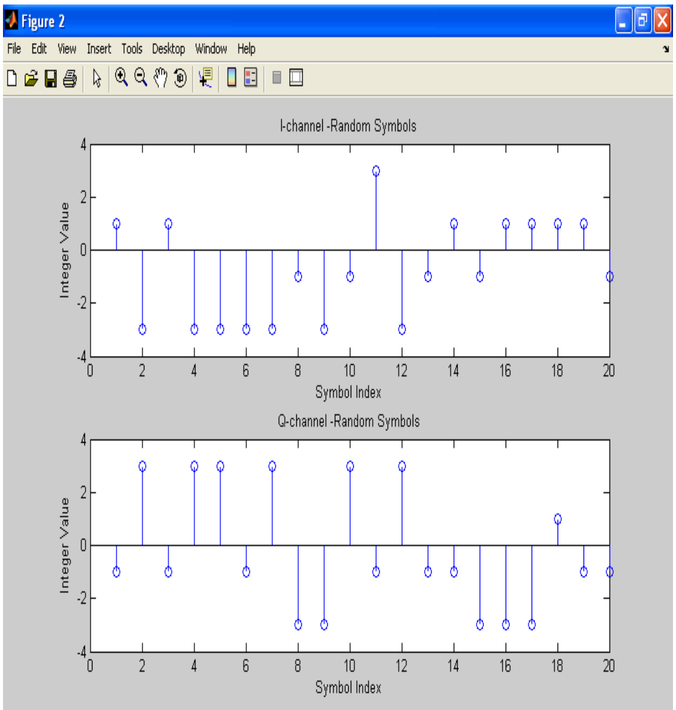

Figure 4.3: Impulse response of RRC filter

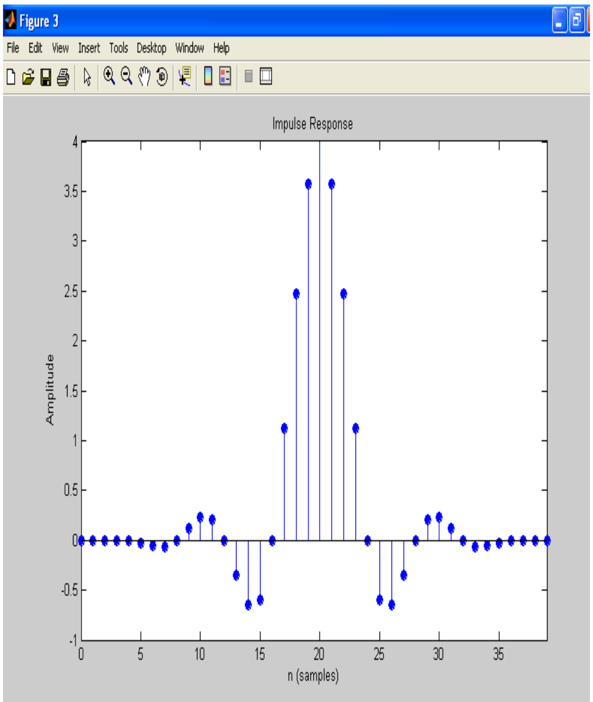

Figure 4.4: Scatter plot of RRC filter

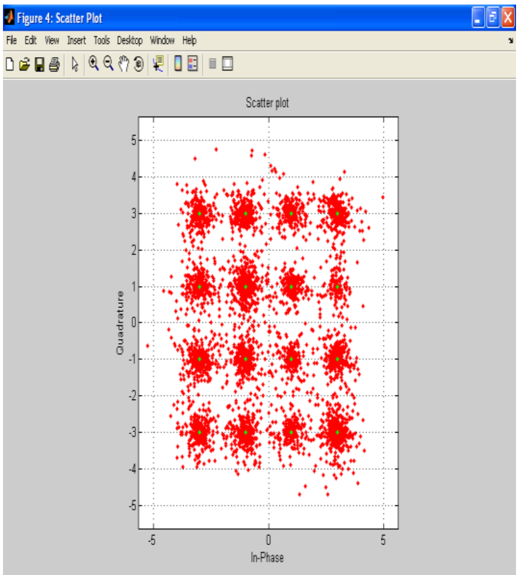

Figure 4.5: Impulse response of RC filter

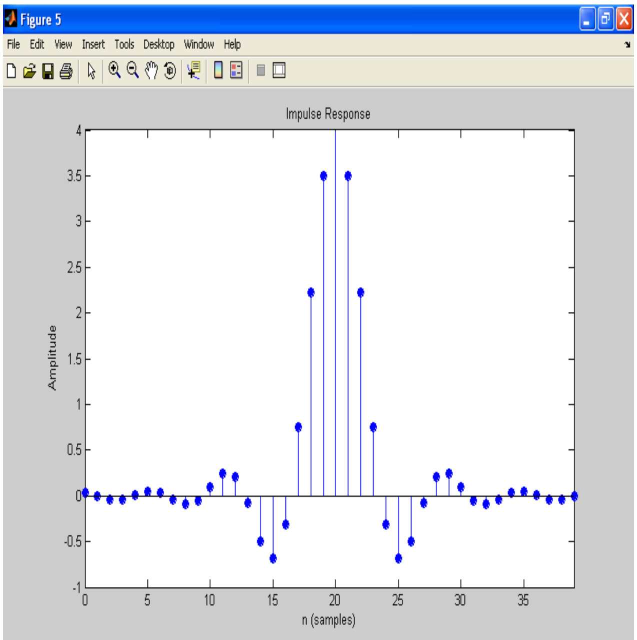

Figure 4.6: Scatter plot of RC filter

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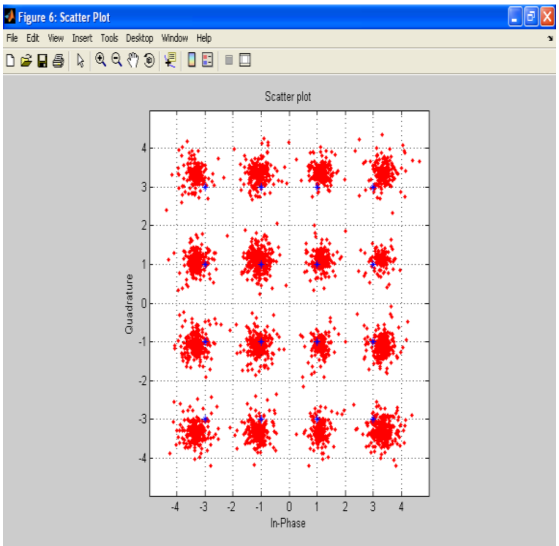
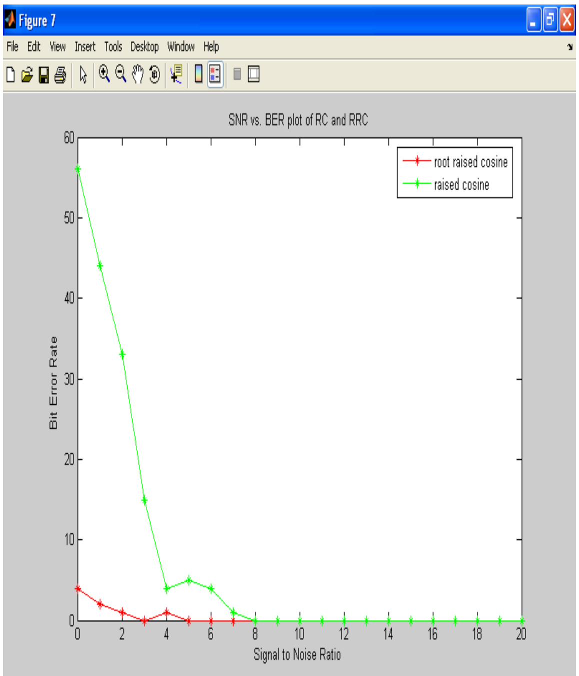


Figure 4.7: Plot of RRC and RC filter-Bit Error Rate



5. Conclusion

16 QAM base band communication system using Raised Cosine and Root Raised Cosine pulse shaping filters is designed and implemented on the MATLAB platform. This is tested for different SNR conditions in the channel ranging from 0 db to 20db and the results are plotted for Raised Cosine and Root raised cosine communication systems. Results are also proved that ISI, Co-channel interference and additive noise are also suppressed over the band-limited channels by using these pulse-shaping filters.

VIII References:

[1] Proakis, John G. Communication Systems Engineering. 2nd ed. New Jersey: Prentice Hall, 2002.

[2] Proakis, John G. Digital Communications.4th ed. McGraw-Hill International Edition, 2001.

[3] Haykin, Simon. Communication Systems. 4th ed. New York: John Wiley and Sons, Inc., 2001,

[4] Sklar, B. Digital Communications. New Jersey: Prentice Hall, 1988,

[5] Wayne Tomasi , Electronic Communications Systems Fundamentals ThroughAdvanced, 4th ed.Asia:Pearson Education,2002

[6] Sam Shanmugam , Digital and Analog Communication Systems, New York:John Wiley and Sons,

[7] Proakis, John G. Digital Signal processing, 4th ed. McGraw-Hill International Edition, 2001.

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