International Journal of Engineering Research and Development (IJERD) ISSN: 2278-067X
Recent trends in Electrical and Electronics & Communication Engineering
(RTEECE 17th – 18th April 2015)

Comparative Review of Different Pulse Shapes for Reduced ISI in Digital Communication

Monica Solanki[1], M A Lokhandwala[2]
[1]Department of Electronics and Communication, Parul Institute of Engineering & Technology, India
[2]Department of Electronics and Communication, Parul Institute of Engineering & Technology, India
[1]solankimonicag@gmail.com
[2]mal_piet@yahoo.com

Abstract:- Recent Communication system demands for transmission of high data rate within a given limited spectrum. When the channel bandwidth is close to the signal bandwidth it would result into Inter Symbol Interference. Therefore there is a need of proper Pulse shaping technique which allows transmitting data within a limited bandwidth with minimum Inter Symbol Interference. This paper includes the comparison of different pulses nominated by Beaulieu and Assalini that has better performance in terms of Inter Symbol Interference.

Keywords:- Inter Symbol Interference, Pulse Shaping, Nyquist Criterion, Raised Cosine Pulse, Roll-off factor.

I. INTRODUCTION

In the recent Communication System the bandwidth is one of the most important resources of the Communication System. Also there is an upgrading demand for the high data rate. But as there is limited frequency resource available we need to limit the bandwidth. Transmitting the information through a band limited channel whose signal bandwidth is nearby to the channel bandwidth would result into Inter Symbol Interference which can be problematic at the time of reception at the receiver end if it is left uncontrolled [3].

II. INTER SYMBOL INTERFERENCE

Inter Symbol Interference is one type of effect observed on a signal in which one symbol gets interfere with adjacent symbols. ISI effect is usually caused when transmitting a signal through a band limited channel or due to the multipath propagation. Due to the presence of ISI in the Communication System introduces errors in the decision device at the receiver output [4]. Therefore, to diminish the effects of ISI, and thereby deliver the information to its destination with the smallest probability of errors there is required pulse shaping which can allow transmitting information within the limited bandwidth and with reduced effect of ISI.

III. PULSE SHAPING

In the Communication System to transmit the information within the required bandwidth and to reduce the effect of ISI there is required a Pulse shaping techniques. In this paper variant pulses have being presented which can decay faster and can reduce the effect of ISI. Usually the frequently used pulse shaping technique in Digital Communication System is Nyquist pulse also known as the Raised Cosine pulse which not only satisfies the Nyquist criterion but which can also decay faster. There are other pulses also which work better than the raised cosine pulse. Nyquist criterion tells that pulse should have zero crossing at the sampling point of all pulse intervals except its own.

The raised cosine pulse with its frequency response and the impulse response characteristic is defined as [2]

$$H1(f) = \begin{cases} 1, & |f| \le fn(1-\alpha) \\ \frac{1}{2} + \frac{1}{2}\cos\left(\frac{\pi}{2fn\alpha}\left(|f| - fn(1-\alpha)\right)\right), & fn(1-\alpha) \le |f| \le fn(1+\alpha) \\ 0, & fn(1+\alpha) \le |f| \end{cases} \qquad \text{Eq. (1)}$$

$$h1(t) = sinc\left(t/T_s\right)\frac{\cos(\pi\alpha t/T_s)}{1-(2\alpha t/T_s)^2} \qquad \text{Eq. (2)}$$

Where α is the roll-off factor which shows the excess bandwidth used over the ideal bandwidth $fn = 1/(2T_s)$ is the Nyquist frequency and Ts is the symbol time.

New nominated pulse [2] was referred to it as *flipped exponential* (fexp) pulse.

$$H2(f) = \begin{cases} 1, & |f| \le fn(1-\alpha) \\ exp(\beta(fn(1-\alpha) - |f|)), & fn(1-\alpha) < |f| \le fn \\ 1 - exp(\beta(|f| - fn(1+\alpha))), & fn < |f| \le fn(1+\alpha) \\ 0, & fn(1+\alpha) < |f| \end{cases} \qquad \text{Eq. (3)}$$

$$h2(t) = \frac{1}{T_s} sinc\left({t}/{T_s}\right) \frac{4\beta\pi t \, \sin\left({\pi\alpha t}/{T_s}\right) + 2\beta^2 \cos\left({\pi\alpha t}/{T_s}\right) - \beta^2}{(2\pi t)^2 + \beta^2} \qquad \text{Eq. (4)}$$

Where $\beta = {\ln 2}/{(\alpha\, T_s)}$

The other two new pulses presented by [1] flipped hyperbolic secant (fsech) pulse and flipped inverse hyperbolic secant (farcsech) pulse.

The frequency and impulse response of the *flipped hyperbolic secant* (fsech) pulse is

$$H3(f) = \begin{cases} 1, & |f| \le fn(1-\alpha) \\ \operatorname{sech}\left(\gamma\left(|f| - fn(1-\alpha)\right)\right), & fn(1-\alpha) < |f| \le fn \\ 1 - \operatorname{sech}\left(\gamma(fn(1+\alpha) - |f|)\right), & fn < |f| \le fn(1+\alpha) \\ 0, & fn(1+\alpha) < |f| \end{cases} \qquad \text{Eq. (5)}$$

$$h3(t) = \frac{1}{T_s} sinc\left({t}/{T_s}\right) \left\{ 8\pi t \sin\left({\pi\alpha t}/{T_s}\right) F_1(t) + 2\cos\left({\pi\alpha t}/{T_s}\right)[1 - 2F_2(t)] + 4F_3(t) - 1 \right\} \qquad \text{Eq. (6)}$$

Where $\gamma = {\ln\left(\sqrt{3}+2\right)}/{(\alpha\beta)}$, and

$$F_1(t) = \sum_{k=0}^{+\infty} (-1)^k \frac{(2k+1)\gamma}{\left((2k+1)\gamma\right)^2 + (2\pi t)^2},$$

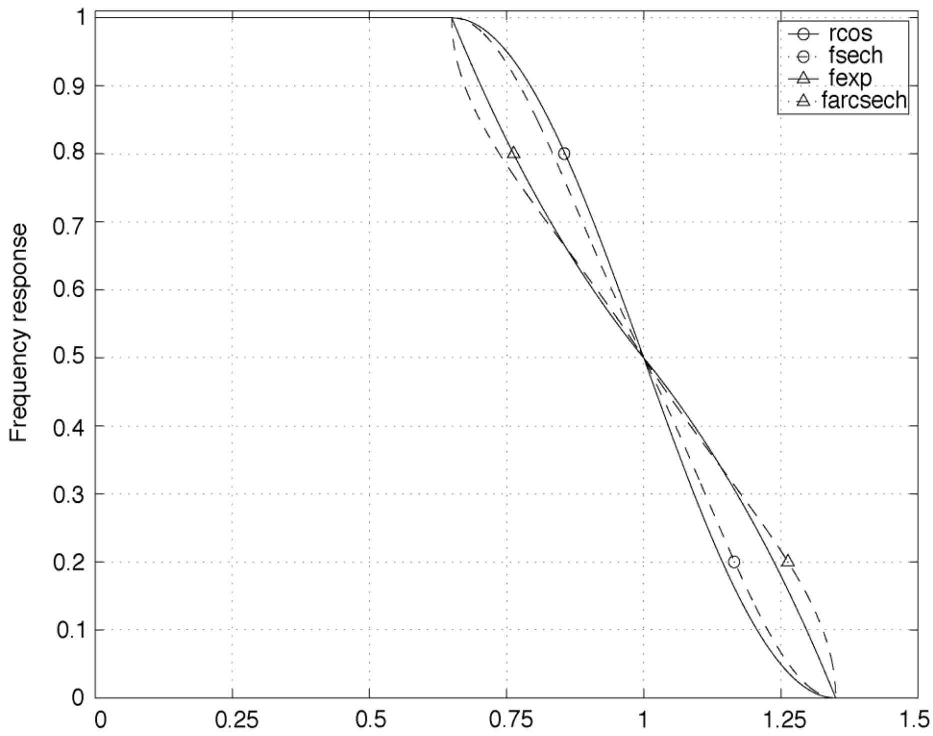
$$F_2(t) = \sum_{k=0}^{+\infty} (-1)^k \frac{(2\pi t)^2}{\left((2k+1)\gamma\right)^2 + (2\pi t)^2},$$

$$F_2(t) = \sum_{k=0}^{+\infty} (-1)^k \frac{(2\pi t)^2}{\left((2k+1)\gamma\right)^2 + (2\pi t)^2} \, e^{-(2k+1)\frac{\alpha\gamma}{2T_s}}$$

The frequency and impulse response of the *flipped inverse hyperbolic secant* (farcsech) pulse is

$$H4(f) = \begin{cases} 1, & |f| \le fn(1-\alpha) \\ 1 - \frac{1}{2\alpha fn\gamma} \operatorname{arcsech}\left(\frac{1}{2\alpha fn}(fn(1+\alpha) - |f|)\right), & fn(1-\alpha) < |f| \le fn \\ \frac{1}{2\alpha fn\gamma} \operatorname{arcsech}\left(\frac{1}{2\alpha fn}\left(|f| - fn(1-\alpha)\right)\right), & fn < |f| \le fn(1+\alpha) \\ 0, & fn(1+\alpha) < |f| \end{cases} \qquad \text{Eq. (7)}$$

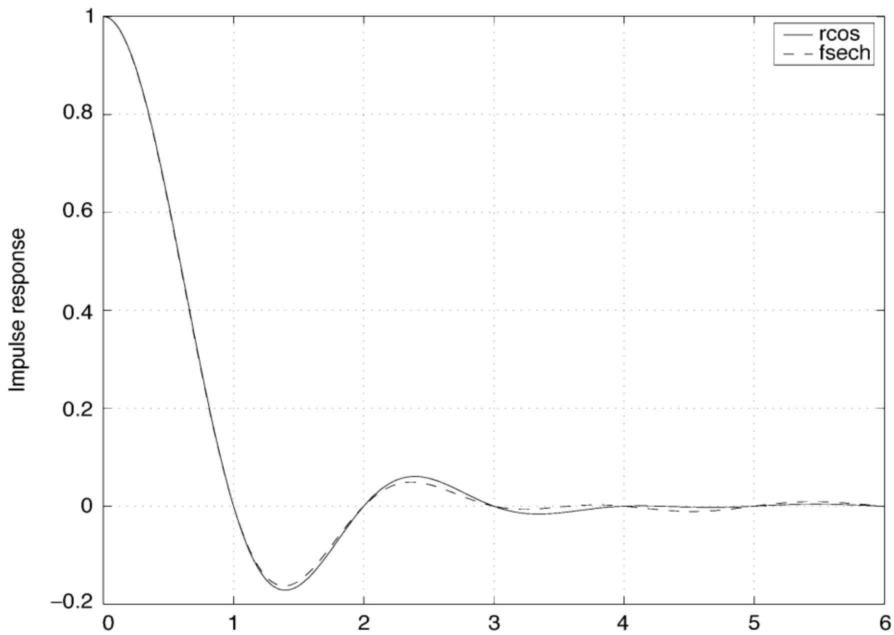
The frequency response characteristic of different pulse shapes are plotted in Fig. 1



(f/fn)

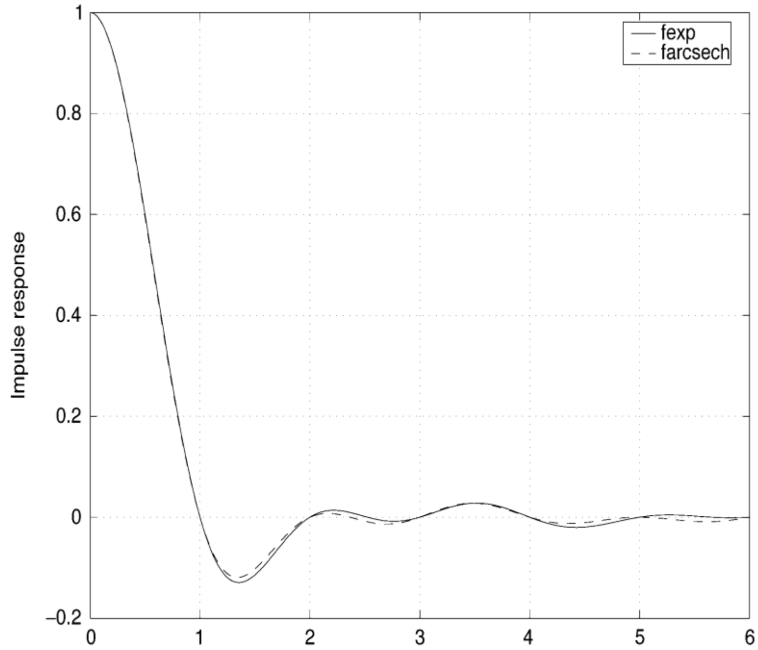
Fig.1: Frequency response characteristics of all the nominated pulses for α = 0.35

The impulse response of the pulses is compared by keeping the roll-off factor = 0.35. The side lobes of the nominated pulses decays faster hence the error probability decreases.



(t/Ts)

(a)



(t/Ts)

(b)

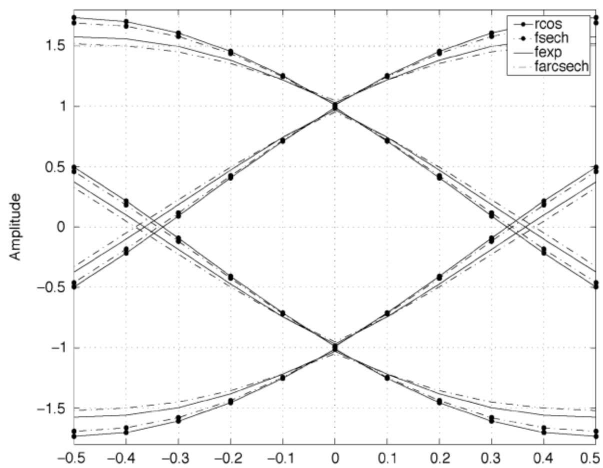
Fig.2: Impulse response for all the nominated pulses for
α = 0.35 (a) Asymptotic decay as t^{-3} (b) Asymptotic decay as t^{-2}

Figure shows that $h_1(t)$ and $h_3(t)$ pulses decays at t^{-3} while $h_2(t)$ and h_4 (t) pulses obtained by taking Fourier transform decays at t^{-2}.

From fig.(a) fsech pulse is better than the rcos pulse. Similarly from fig.(b) the farcsech pulse is better than the fexp pulse.

Comparing all these pulses it can be noted that the farcsech pulse amplitude decays faster compare to all other pulses. Thus farcsech pulse is better from all other pulses.

Fig. 3 shows the eye diagrams for the Nyquist pulse and all other nominated pulses. The new pulses have more open eye compare to earlier propose raised cosine pulse.



(t/Ts)

Fig.3: Eye diagram for the nominated pulses with only inner-outer contours for α = 0.35

The farcsech pulse has more eye width compare to fexp pulse and fsech has more eye width compare to the rcos pulse. After all it shows that farsech pulse has maximum eye width compare to all other pulses. The new nominated pulse has minimum effect of ISI that is the error probability due to sampling time error decreases at the receiver end.

IV. CONCLUSION

A nominated new Nyquist pulse by Assalini performs better than the pulses nominated by Beaulieu. A new pulses fsech and farcsech pulses has smaller error probability and maximum eye width at the receiver end compared to the rcos pulse and the fexp pulse. Also the new pulse decays faster than the rcos pulse. From all these pulses farsech pulse outperforms all other pulses in terms of minimum amplitude of first sidelobe and max eye width which in turn shows that it reduces the effect of ISI. Thus a pulse shaping techniques used in Communication should be such that it requires minimum excess bandwidth and controlled effect of Inter Symbol Interference.

REFERENCES

[1]. Assalini , Tonello, “Improved Nyquist Pulses”, IEEE Communications letters, Vol 8, No.29, pp 87-89, Feb. 2004.
[2]. Beaulieu, Tan, and Damen, *“*A “Better Than” Nyquist, Pulse”, IEEE Communications letters, Vol 5, No. 9 , pp 367 – 368, Sept. 2001
[3]. Chattopadhyay, Sanyal, *“*The Effect of Gaussian Pulse –Shaping Filter Roll-off Factor on the Performance of QPSK Modulated System,” IEEE Signal, Circuits and System, Vol-09, pp 1 – 4, 2009.
[4]. Chopra, Tomar, “The Effect of Inter Symbol Interference on Optical Communication System,” International Journal of Engineering Sciences & Research Technology, 2(7) , pp 1787-1789, 2013