

# Improving Spectral Efficiency in Space Communications using SRRC Pulse-Shaping Technique

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**Abstract**—This paper proposes an improved spectral efficiency in space communications using square root raised cosine (SRRC) pulse-shaping technique. The proposal is necessitated by the global shortage of bandwidths confronting the wireless communication system. The major contribution of this technique is its ability to reduce the channel bandwidth and eliminate inter-symbol interference and spectral seepages with ease. This is achieved by tightly constraining wider channel bandwidths in a given frequency spectrum using SRRC pulse-shape filtering, thus eliciting more channels, higher data rates per channel and more users in the system. To authenticate the rationality of the proposed technique, MATLAB simulations are carried out under varying SRRC filter roll-off factors. The proposed technique is capable of achieving 43.76% channel bandwidth improvement, which is close to an ideal case of 50%. This is a great achievement in band-limited communication system. It is envisioned that this technique will be very helpful to designers of high performing and bandwidth efficient space communication system.

**Index Terms**—Inter-Symbol Interference; Pulse-Shaping; Raised Cosine Filter; Spectral Efficiency; Square Root Raised Cosine Filter.

## I. INTRODUCTION

Pulse-shape filtering is a vital phenomenon in wireless communication system due to its ability to reduce overall carrier transmission power and channel width as well as eliminate spectral seepages and ISI. The grand purpose of pulse-shaping in digital communication is to make the transmitted signal's bandwidth match that of the communication channel, by limiting the effective bandwidth of the signal. In multi-channel communication systems, limiting all the power of the modulated carriers to just the carrier bandwidth leads to more concentrated frequency band with reduced overall transmission power and improved spectral efficiency. The spectral efficiency of a transmission system, which is the amount of transmitted information that can fit into a given channel bandwidth is expressed in bits/s/Hz. By limiting a channel to the specific frequency band, therefore, helps in eliminating adjacent channel interference [2, 3].

In bandwidth-limited digital data transmission systems, pulse-shaping technique is mostly employed to constrain the signal bandwidth and minimize the likelihood of decoding

errors at the receiver. This technique can be achieved by using root raised cosine (RRC) filtering. The RRC spectrum manifests a good characteristic of odd symmetry about  $1/2\tau$ , where  $\tau$  is the transmission symbol period. Although pulse-shaping technique has been used in commercial communication systems such as cellular technology over the years, it is still relatively new in space communications [4]. With the global congestion of frequency spectrum in space communications, it is imperative to look into diverse techniques that can improve the spectral efficiency. It is pertinent to note that space communication systems have stringent requirements of high data rates per channel and narrow channel bandwidth. However, as the size of the channel bandwidth increases in the course of providing high data rates, the number of channels allotted in a fixed spectrum must be proportionally limited. In order to address these two scenarios (i.e. generating band limited channels and reducing ISI without compromising each other, the RRC filtering technique needs to be employed. The technique involves tightly packing wider channel bandwidths in the frequency spectrum to achieve high data rates per channel as well as more channels in the system. The filtering efficiency can be further improved by adjusting the filter order. Using RRC filtering in space communication transmitter and receiver can improve spectral efficiency and bit error rate (BER) performance of the system [5].

Theoretically, high data rates in communication systems imply that more information can be transmitted through the channel [6]. When the channel bandwidth is reduced to a narrower band by compressing the signal bandwidth, there will be more channels, more users and less noise in the system. However, if the channels are too narrow, the symbols will be too wide and will lead to ISI. To correct this effect, an ideal low-pass filter (ILPF) can be used to filter the transmitted signal. The spectrum of the transmission can, therefore, be determined by the pulse-shaping filter.

## II. PULSES IN DIGITAL COMMUNICATIONS

### A. Rectangular Pulse Energy

In digital communications, data can be transmitted in bits (binary digits) or symbols (group of bits) in form of pulses of energy. The most fundamental of these pulses is the