Digital Modulation using Complex-Exponential Basic functions and Orthogonal Pulse-Shapes

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Abstract

This paper proposes a new modulation technique that doubles the transmission rate of data symbols in digitally modulated systems. The rate is doubled with no changes in the used signal constellation or the modulated signal bandwidth. The proposal doubles the transmission rate by sending two independent complex symbols simultaneously on a real sinusoidal carrier. This is achieved by using Complex-Exponential Carriers (CECs) instead of Real-Sinusoidal Carriers (RSCs). Each CEC of the two conjugate-symmetry exponentials of the RSC is modulated with a different complex modulating symbol. The time-domain samples of the modulated signals are complex. Two orthogonal pulses reshape the real and imaginary parts of the complex-modulated symbols. The reshaped symbols are added to form one real-modulated signal. The reshaping pulses are chosen to be Hilbert-Transform pair. The bandwidth efficiency of the proposed system is double the bandwidth efficiency in systems use RSCs.

Keyword:

Digital modulation; exponential carriers; orthogonal pulse shapes; Hilbert transform; inter-symbol interference.

1. Introduction

Many works focus on improving the performance of digital communication systems in linear and time-varying channels. Some works are interested in the power efficiency of digitally modulated systems. They improve the power efficiency by using channel coding and space-diversity techniques [1-5]. A combination of channel coding and space diversity took a lot of interests in the last decades. Many efforts are spent in this research area. These efforts are crowned with the appearance of Multiple-Input-Multiple-Output (MIMO) systems. MIMO systems give good performance in time-varying channels. MIMO systems are used in many wireless applications such as WIFI and WIMAX networks [6,7].

Other works focus on improving the bandwidth efficiency of the communication system. They try to maximize the number of data symbols transmitted in the bandwidth of the modulated signal. High-order modulation scheme is an example of improving the bandwidth efficiency in narrow-band digital-modulation systems [8]. In this scheme, bigger signal constellation is used to encode **b** data bits to one symbol from $\mathbf{2^b}$ symbols according to the used modulation method.

Some other modulation systems are developed to improve the ability to resist interference at the expense of the bandwidth efficiency. Direct-Sequence-Spread-Spectrum (DSSS) systems and frequency-division-multiplexing (FDM) systems are examples of these systems. Because the bandwidth efficiency of DSSS and FDM systems are low, Code-Division-Multiple-Access (CDMA) systems and Orthogonal-Frequency-Division-Multiplexing (OFDM) systems are developed to improve the bandwidth efficiency of DSSS and FDM systems respectively [9, 10].