



## Performance analysis of broadband satellite communication system based on OFDM/TDM

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### Abstract

Orthogonal frequency division multiplexing (OFDM) is attracting more attention for its capability of high speed transmission. However, the OFDM possesses an obvious shortage in its high ratio of the peak power to the average power (PAPR), which has become the main issue holding it back to be applied to the broadband satellite communication system. OFDM combined with time division multiplexing (TDM), dividing the subcarriers of OFDM into some blocks in time tune, can decrease the high PAPR of OFDM. Meanwhile, the advantages of OFDM can be preserved. In this paper, OFDM/TDM is applied to the broadband satellite communication system. This paper theoretically analyses OFDM/TDM system model as well as its restraining effect on PAPR, and proposes frequency domain multiplexing-pilot (FDM-Pilot) channel estimation algorithm. Simulation results show OFDM/TDM in broadband satellite communication system has approving performance and decreased the PAPR.

**Keywords** OFDM/TDM, broadband satellite communication system, PAPR, channel estimation

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### 1 Introduction

The broadband satellite communication system, which has been dramatically developed to meet a fast growing demand of its using, is going to play an important role in the future air-space-ground of integrated communication network. In the past few years, OFDM is successfully applied in various wireless communication systems, e.g. digital video broadcasting (DVB), wireless local area networks (WLAN) [1]. OFDM has the advantages of high spectrum efficiency, robustness to the interference and fitness for the frequency-selective fading, et al. For above reasons, OFDM became one of the key technologies in beyond the 3rd generation mobile communication (B3G) system, the 4th generation mobile communication (4G) system [2]. However, it has not been included in the broadband satellite standards. Many researches are being

considered for the development of a satellite radio interface using OFDM and the study results are being standardized in various standardization bodies [3–5]. So the research of the key technologies using OFDM for the broadband satellite system is essential.

On the other hand, as multicarrier modulation system, OFDM signal is generated from the addition of many of orthogonal subcarrier signals modulated. If the phases of the subcarrier signals are consistent, the instantaneous power of the signal will be far greater than its average power, and it causes large PAPR. The peak power is proportional to the number of subcarriers [1]. High PAPR is the main defect of OFDM, which affects its application in broadband satellite communication system. In the implement, the nonlinear high power amplifier (HPA) with a large dynamic range should be used. Otherwise the peak is in the nonlinear range to lead to the spectrum spread and the increase of the bit error code ratio (BER) caused by signal distortion in band. Therefore, to apply OFDM to

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broadband satellite communication and make it work well, PAPR of the signal must be reduced.

In order to overcome the PAPR problem of OFDM and ensure the system performance and reduce the system complexity, Gacanin et al. proposed to combine OFDM with TDM to form OFDM/TDM system [6–7], which is also called generalized OFDM (GOFDM), this system divides the long inverse fast Fourier transform (IFFT) operation time window of OFDM signal into several blocks, each block contains the reduced the number of subcarriers to reduce the PAPR. Considering the characteristics of OFDM/TDM, OFDM/TDM applied to the broadband satellite communication system can take advantage of OFDM, improve system performance and efficiently utilize the spectrum, and reduce the PAPR of OFDM. This paper theoretically analyses the OFDM/TDM system model and its inhibitory effect of the PAPR, at the same time, proposed a channel estimation method to improve system performance. The computer simulation results are given later, which indicates OFDM/TDM in broadband satellite communication system has approving performance and decreases the PAPR.

## 2 OFDM/TDM system

### 2.1 OFDM/TDM system model

OFDM/TDM system model is proposed based on conventional OFDM system model. OFDM/TDM divides the long IFFT operation time window of OFDM signal into  $K$  blocks, each block contains the reduced the number of subcarriers, at the receiver the demodulation of OFDM/TDM signal is a reverse process. Fig. 1 illustrates the configuration of an OFDM/TDM transmitter/receiver respectively.

In the transmitter, the transmitted data is first converted into parallel data to  $N_c$  subchannels, where the conventional OFDM signal with  $N_c$  subcarriers. Then, the transmitted data of each parallel subchannel is modulated by PSK-based or QAM-based modulation. The sequence of  $N_c$  data-modulated symbols  $\{d(i); i = 0 \dots N_c - 1\}$  with  $|d(i)| = 1$  is to be transmitted during one OFDM/TDM frame. Data-modulated sequence  $\{d(i)\}$  is divided into  $K$  blocks of  $N_m = N_c/K$  symbols each. The  $k$ th block symbol sequence is denoted as  $\{d_g^k(i); i = 0 \dots N_m - 1\}$  for the  $g$ th OFDM/TDM frame, where  $d_g^k(i) = d_g(kN_m + i)$ .

The  $N_m$ -point IFFT is applied to each data block to generate a sequence of  $K$  OFDM symbols with  $N_m$  subcarriers during one IFFT time window. The transmission data rate of one OFDM/TDM frame is kept the same as that of one conventional OFDM signal. The OFDM/TDM signal can be expressed using the equivalent lowpass representation as

$$s_g(t) = \sum_{k=0}^{K-1} s_g^k(t - kN_m)u(t - kN_m) \quad (1)$$

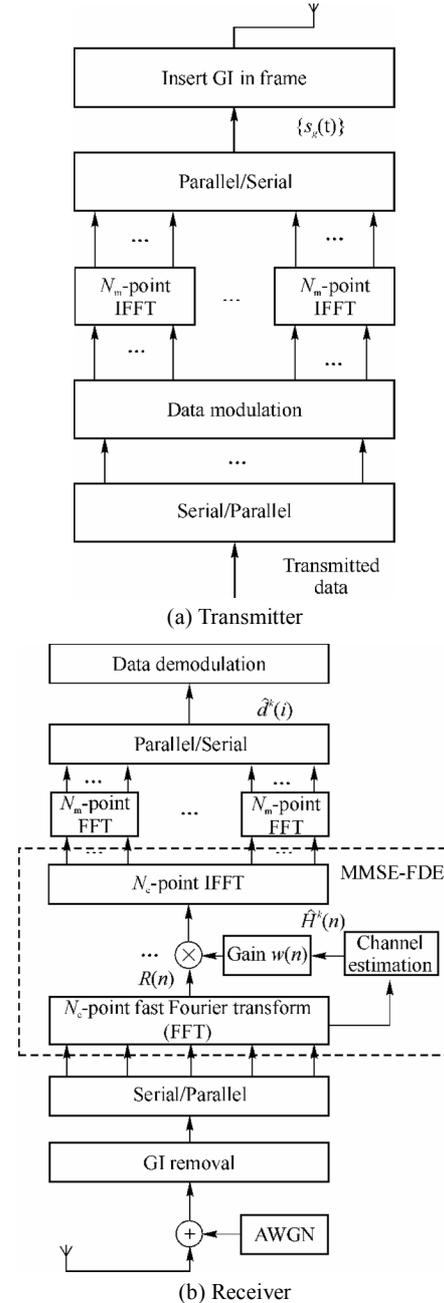


Fig. 1 The configuration of an OFDM/TDM transmitter/receiver

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