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A novel method for PAPR reduction of the OFDM signal using nonlinear scaling and FM

Key words: Orthogonal frequency division multiplexing; Peak-to-average power ratio; Nonlinear scaling; Frequency modulation

Corresponding author: Myoung-seob LIM
E-mail: mslim@jbnu.ac.kr
ORCID: Yi-hu XU, http://orcid.org/0000-0002-7387-1865; Myoung-Seob LIM, http://orcid.org/0000-0001-8978-7660

Motivation

- Orthogonal frequency division multiplexing (OFDM) has been used in high-bit-rate wireless and mobile communication because of its robust transmission under frequency selective fading channel conditions.
- A major disadvantage of OFDM is the generation of non-constant envelope signals with high peak-to-average power ratios (PAPRs). High peak signals in OFDM are distorted by a nonlinear amplifier, which leads to bit error rate (BER) performance reduction.

Main idea

- In this study, we present a scaling method in which the high peak signal above the threshold of the amplification region is nonlinearly downscaled to lower the PAPR.
- The time slot location, where the high peak signal is downscaled, is transmitted using frequency modulation (FM) combined with OFDM, which requires less additional bandwidth than conventional methods.

Method

1. OFDM transmitter with FM for scaling down

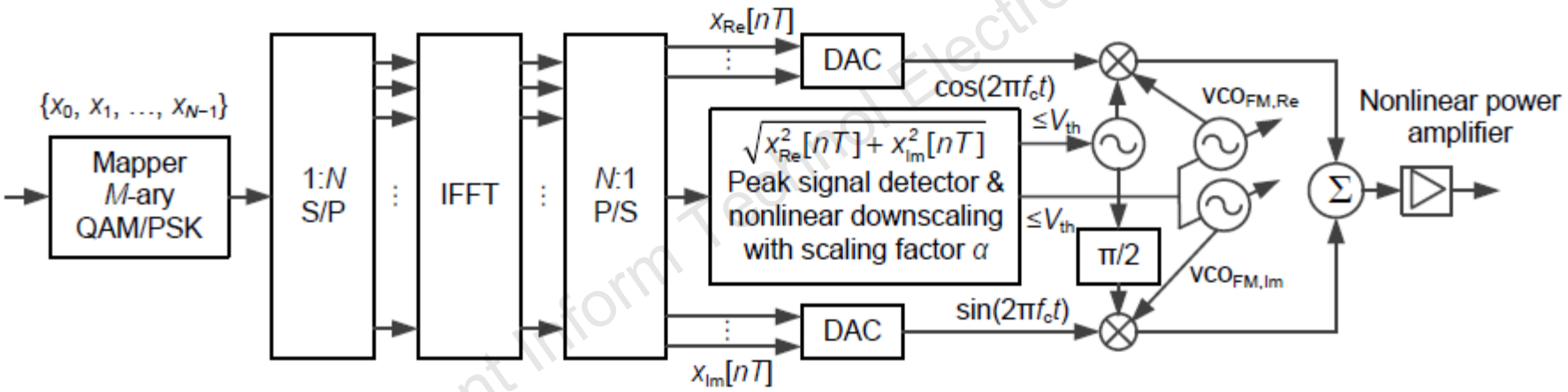

Fig. 4 OFDM transmitter with FM for scaling down

2. OFDM receiver with an FM discriminator for scaling up

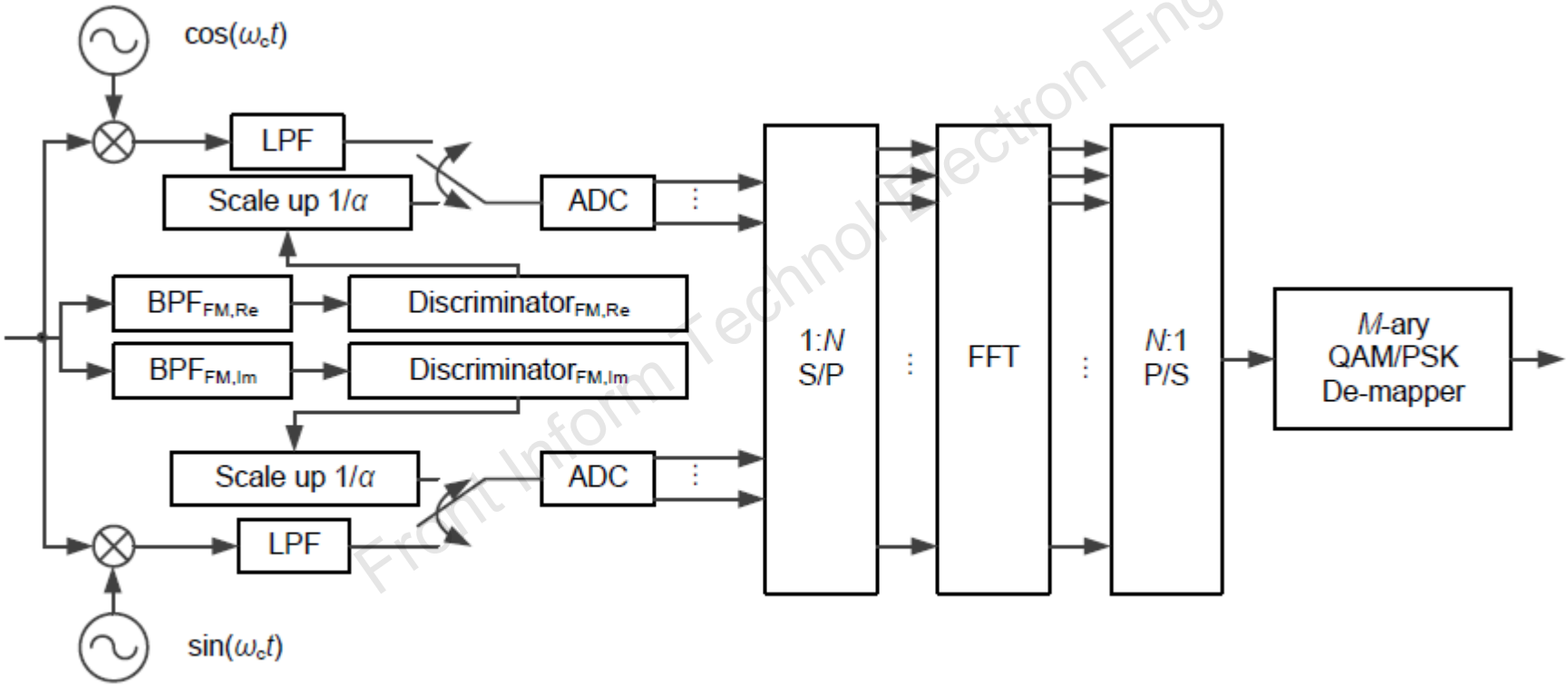

Fig. 5 OFDM receiver with an FM discriminator for scaling up

Major results

Table 1 Comparison of additionally required bandwidth in each PAPR reduction method

Method (QPSK)	Number of bits (side information)	Number of subcarriers	Bandwidth
SM	9 ($\log_2 U$, U=512)	5	$10\Delta f$
PTS	63 ($\log_2 H^{V-1}$, V=64 and H=2)	32	$64\Delta f$
NLSD+FM		2	$4\Delta f$

QPSK: quadrature phase shift keying; SM: selective mapping; PTS: partial transmit sequence; NLSD: nonlinear scaled-down; FM: frequency modulation

Major results

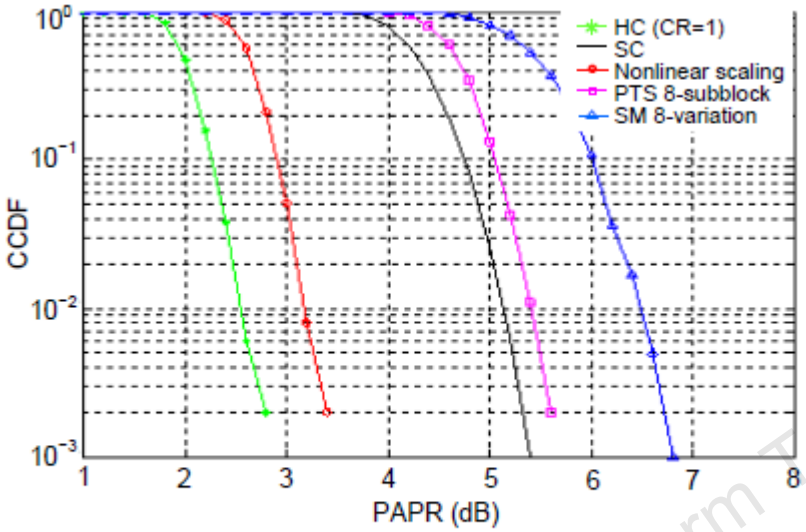

Fig. 6 Comparison of the CCDF performances of several PAPR reduction methods in a 64-subcarrier system

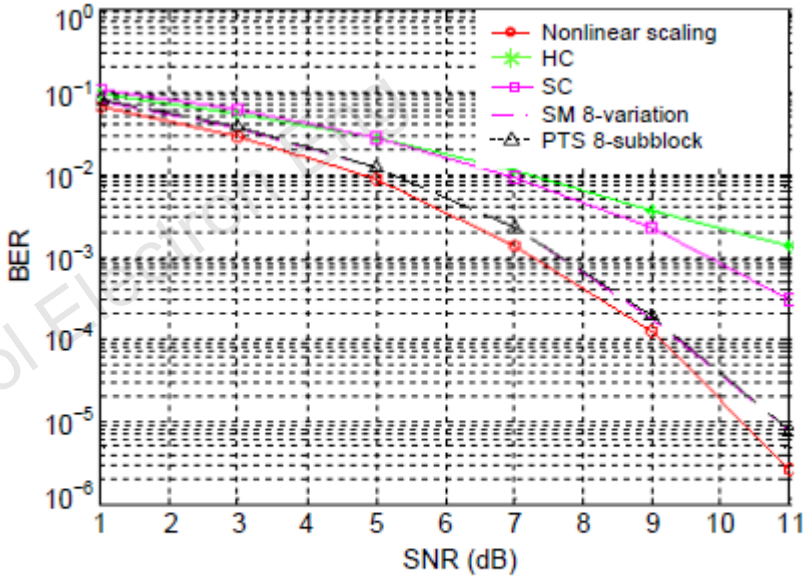

Fig. 7 Comparison of the BER performances of several PAPR reduction methods in a 64-subcarrier system

The clipping method has the narrowest distribution of PAPR considering the envelope fluctuations of the OFDM signal according to all the random input data sequences.

Additive white Gaussian noise (AWGN) is added to the OFDM signal with pre-distortion of the signal for PAPR reduction.

Conclusions

- In the proposed nonlinear scaled-down method, the high peak signal is nonlinearly downscaled, enabling the CCDF of the OFDM signal with the downscaled signals to be close to the CCDF of the clipping method.
- Different from the clipping method, in which the clipped signals cannot be restored at the receiver, the pre-distorted signal for PAPR reduction can be restored, because the scaling ratio and time slot scaling location in the baseband OFDM can be sent to the receiver using FM.
- The proposed method has better CCDF and BER performances than conventional methods.