
Performance Evaluation of OFDM Clipping and Filtering Method Using Transmit Power Control

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Background

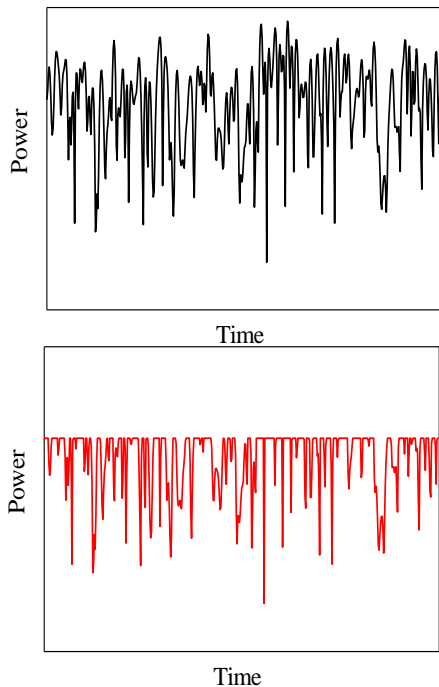
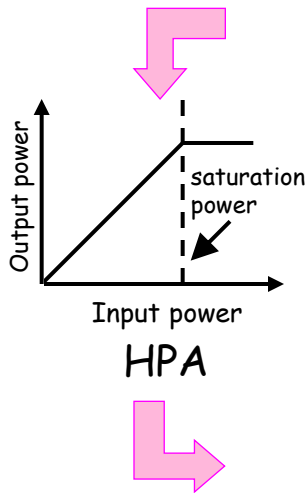
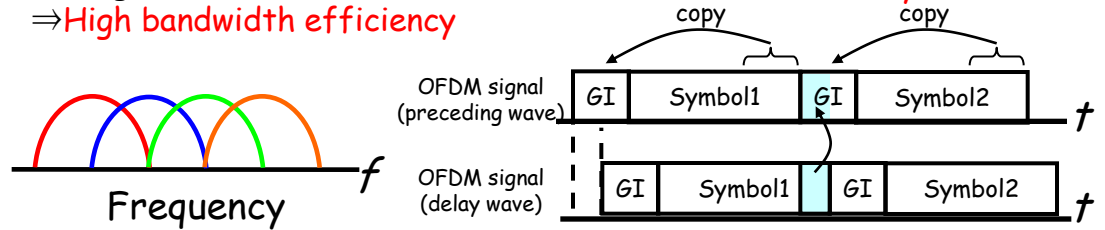
High-speed and high-reliability transmission is required in recent wireless communications systems.

OFDM signal causes a non-linear distortion in the case of power amplification because **PAPR** (peak-to-average power ratio) is extremely high.

OFDM (Orthogonal Frequency Division Multiplexing)

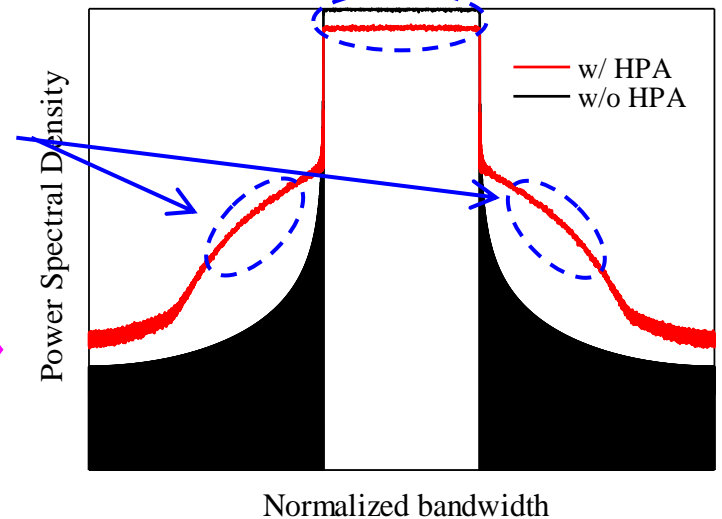
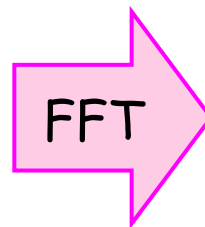
It transmits by using mutually orthogonal subcarriers
 ⇒ High bandwidth efficiency

It inserts a guard interval (GI)
 ⇒ Remove ISI effectively



The degradation of BER by the deterioration in the spectrum in the effective band.

Out-of-band radiation occurs.



Clipping and Filtering (CAF)

Clipping and Filtering (CAF) is practical and effective to cope with the nonlinear distortion problem.

⇒ CAF clips the time domain transmit OFDM signals by clipping and eliminates the out-of-band radiation by filtering at the same time [1].

Clipping

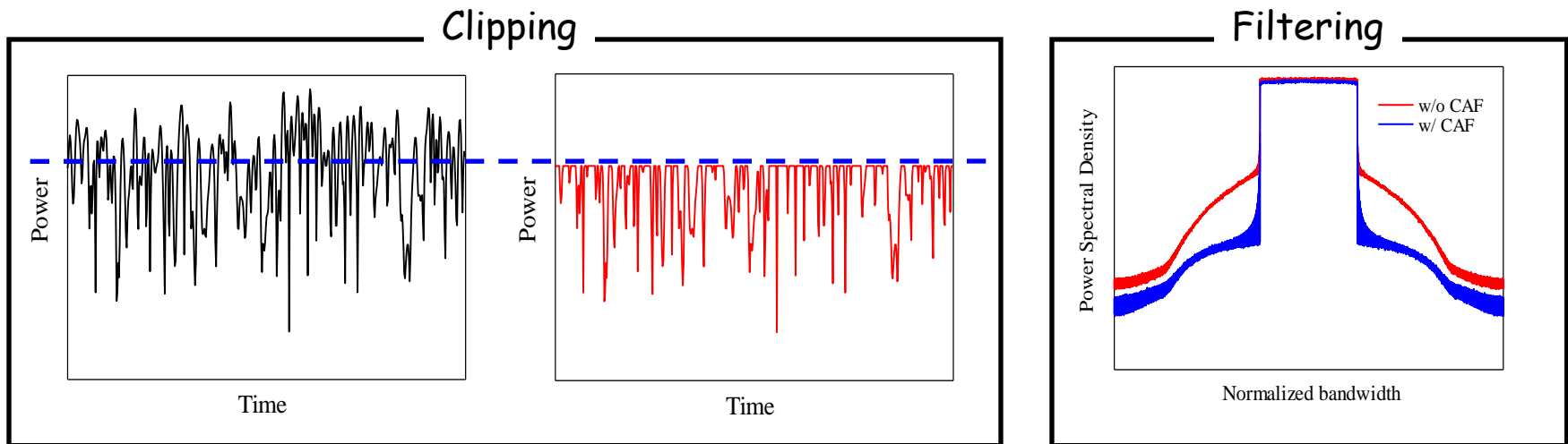
Clipping clips the transmit time domain OFDM signals.

⇒ **Reduction of high peak power**

Filtering

Filtering perfectly eliminates the out-of-band radiation due to the clipping process.

⇒ **Suppression of out-of-band radiation**

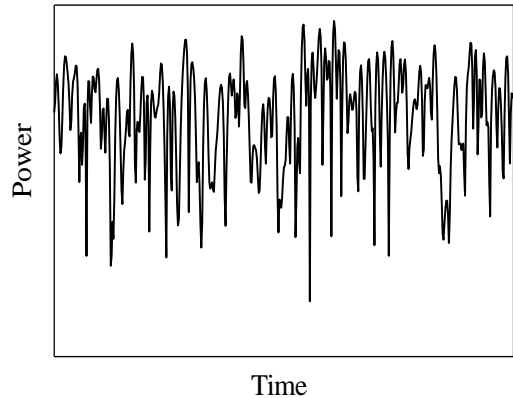


[1] J. Armstrong, "Peak-to-average power ratio reduction for OFDM by repeated clipping and frequency domain filtering," *Elect. Lett.*, vol.38, pp.246-247, Feb. 2002.

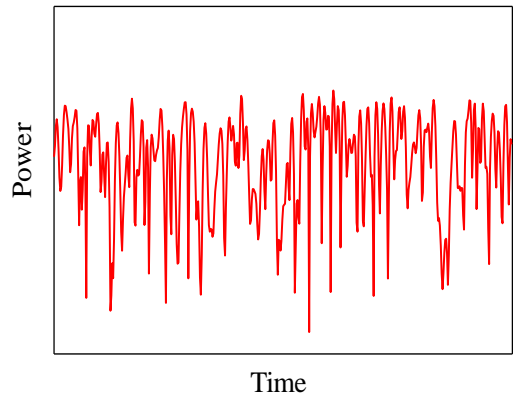
Problem of Clipping and Filtering

OFDM signal after passing through the filter causes the **waveform distortion** due to eliminating the out-of-band radiation.

⇒ **BER performance of the traditional clipping and filtering method is degraded** in comparison with the case without clipping and filtering.



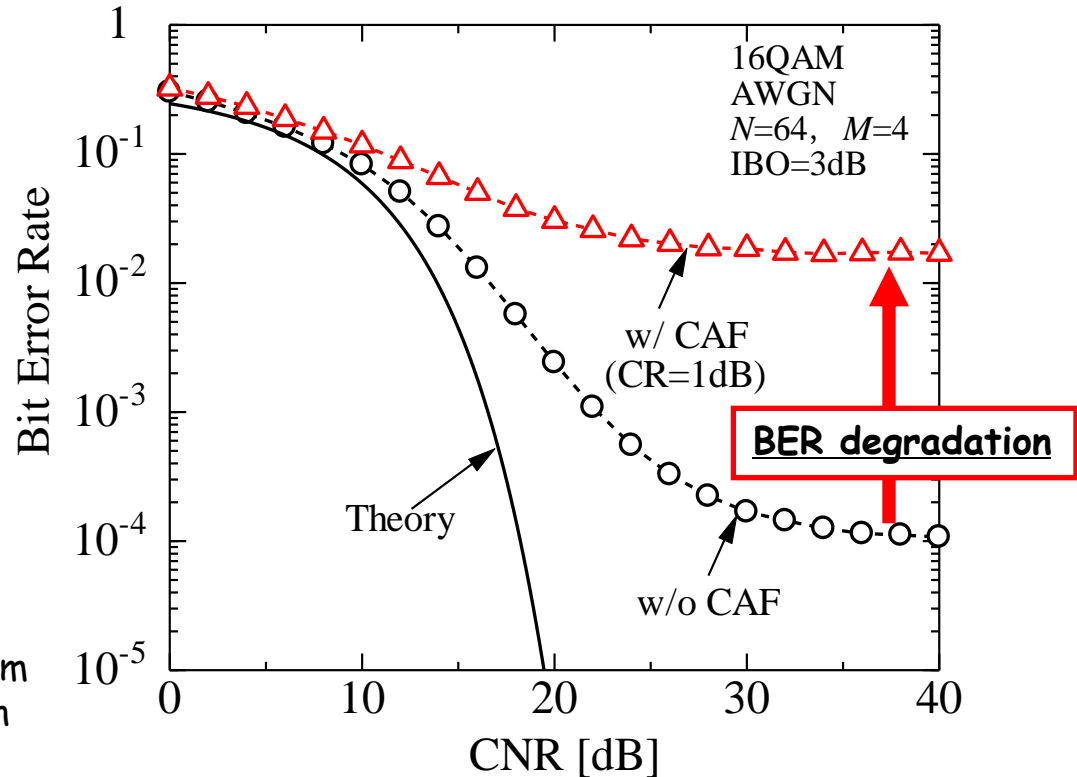
(a) Time waveform before the CAF



(b) Time waveform after the CAF

Waveform mismatch

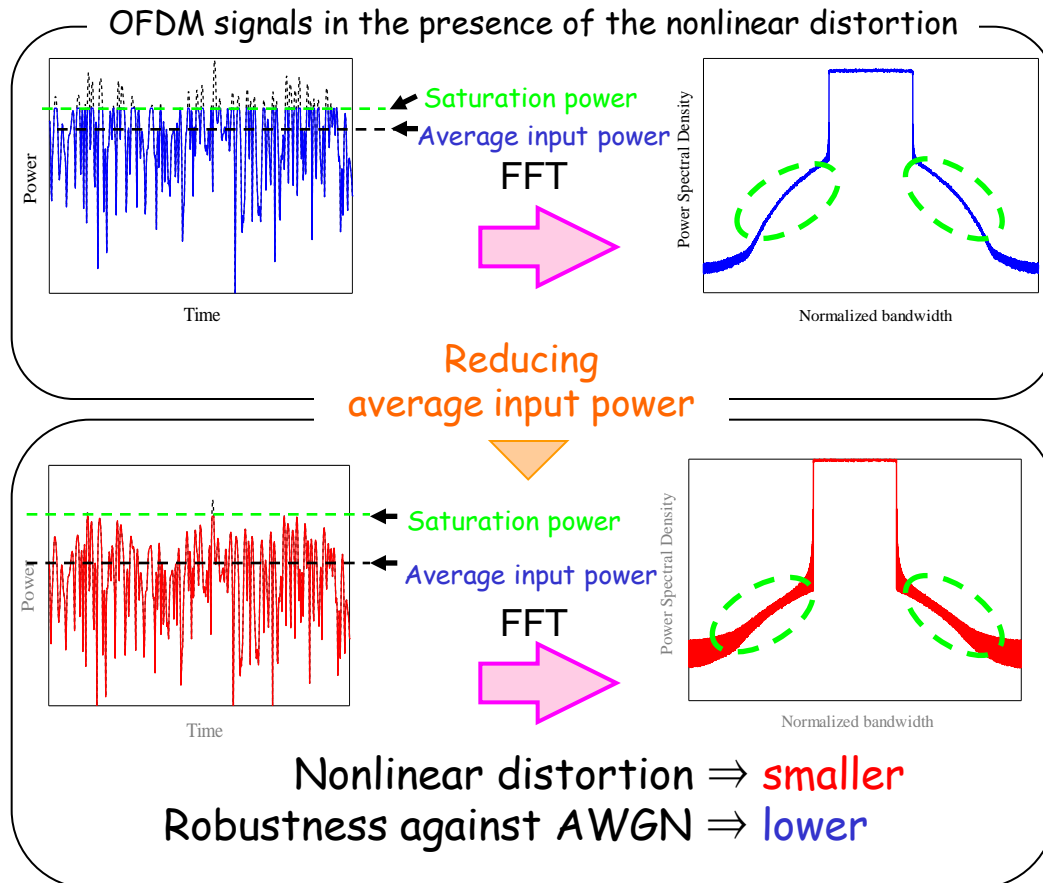
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(c) BER performance versus CNR over AWGN channel

Transmit power control based on the SNDR (1)

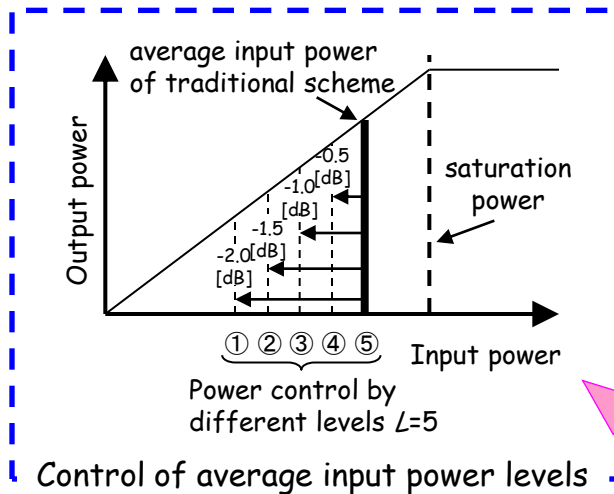
We have so far proposed a symbol-wise transmit power control based on SNDR (signal-to-noise-plus-distortion ratio) **to improve the BER performance in the presence of the nonlinear distortion** [2].



-At the transmitter, the effect of the nonlinear distortion decreases.
- At the receiver, robustness against AWGN weakens.

The transmit power reduction is needed to avoid nonlinear distortion while keeping robustness against AWGN as much as possible.
 \Rightarrow The transmit power control for keeping high signal-to-noise-plus-distortion ratio (SNDR).
 \Rightarrow It is expectable to realizing avoidance of the nonlinear distortion and **improvement of BER**.

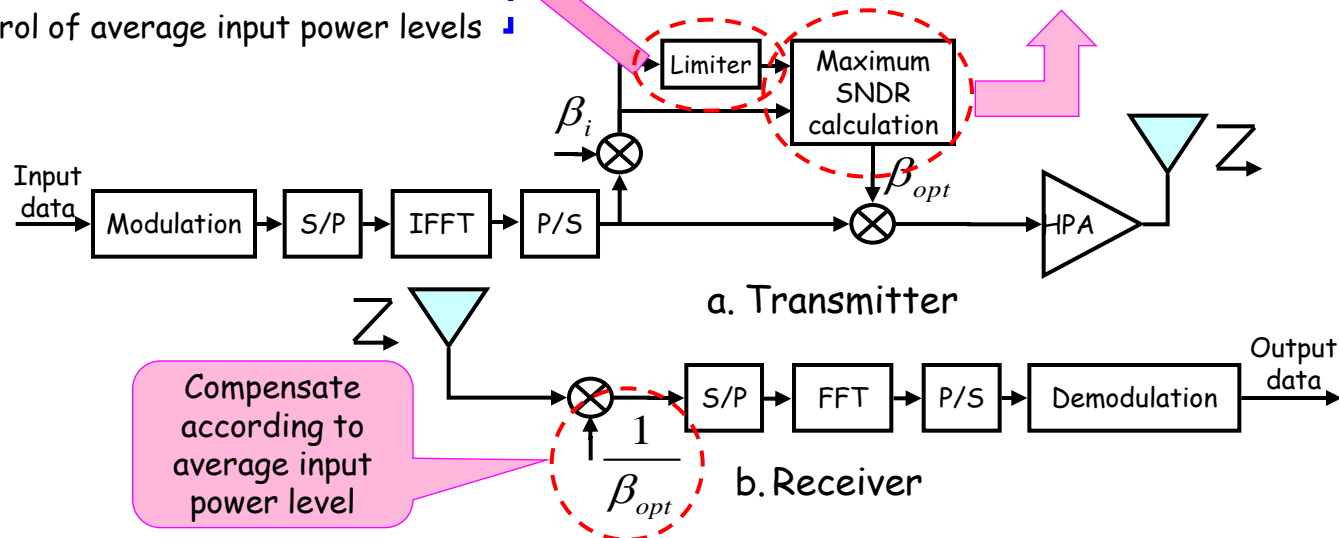
Transmit power control based on the SNDR (2)



Formula of SNDR Γ [3]

$$\Gamma = \frac{S}{D + N} = \frac{|\alpha|^2 \cdot R_{ss}}{R_{s_d s_d} - |\alpha|^2 \cdot R_{ss} + R_{ss} / \Gamma_0}$$

- α : The attenuation coefficient for stationary input processes
- R_{ss} : The input autocorrelation function
- $R_{s_d s_d}$: The output autocorrelation function
- Γ_0 : The average CNR in the symbol is notified from the receiver

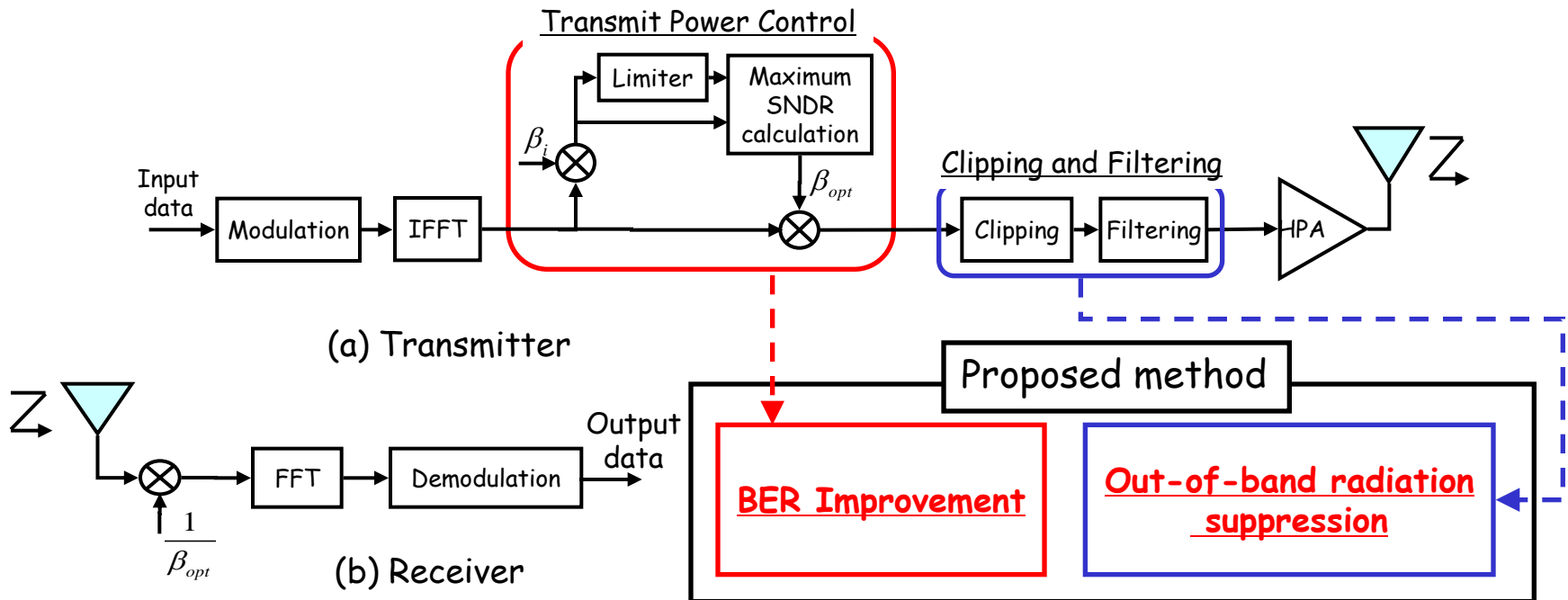


[3] F. Maehara, "Series expression of BER performance for DQPSK/OFDM signals employing selection combining diversity reception over non-linear fading channels," *Proc. IEEE VTC2005-Spring*, vol.2, pp1007-1011, May 2005.

Objective

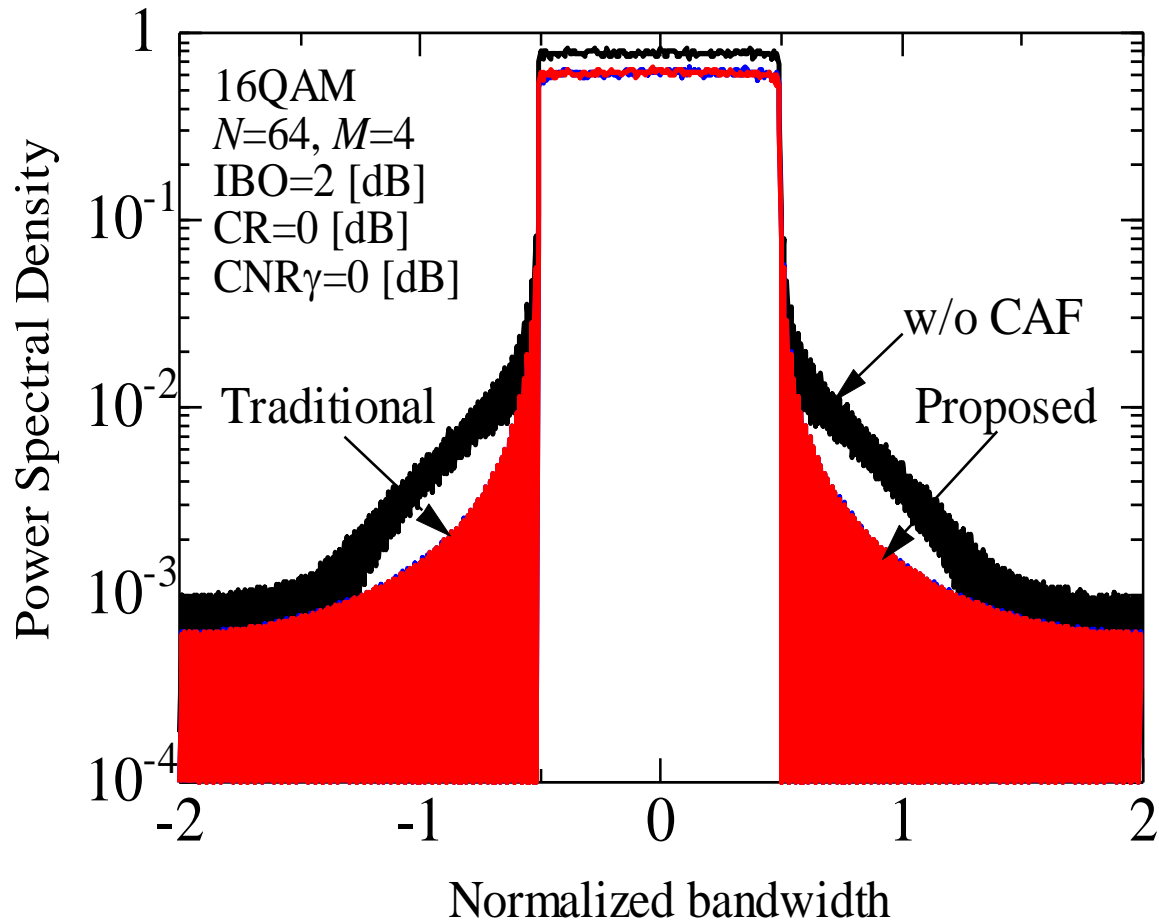
We adopt the transmit power control using the SNDR for clipping and filtering in order to overcome the BER degradation while good out-of-band radiation performance holds.

⇒ In the proposed method, since the transmit power control is performed before clipping and filtering, not only out-of-band radiation suppression thanks to clipping and filtering, but also the BER performance improvement thanks to transmission power control can be expected.



The effectiveness of the proposed method is demonstrated by comparing with the traditional clipping and filtering method with constant input power level with a parameter of the modulation scheme.

Frequency spectrum

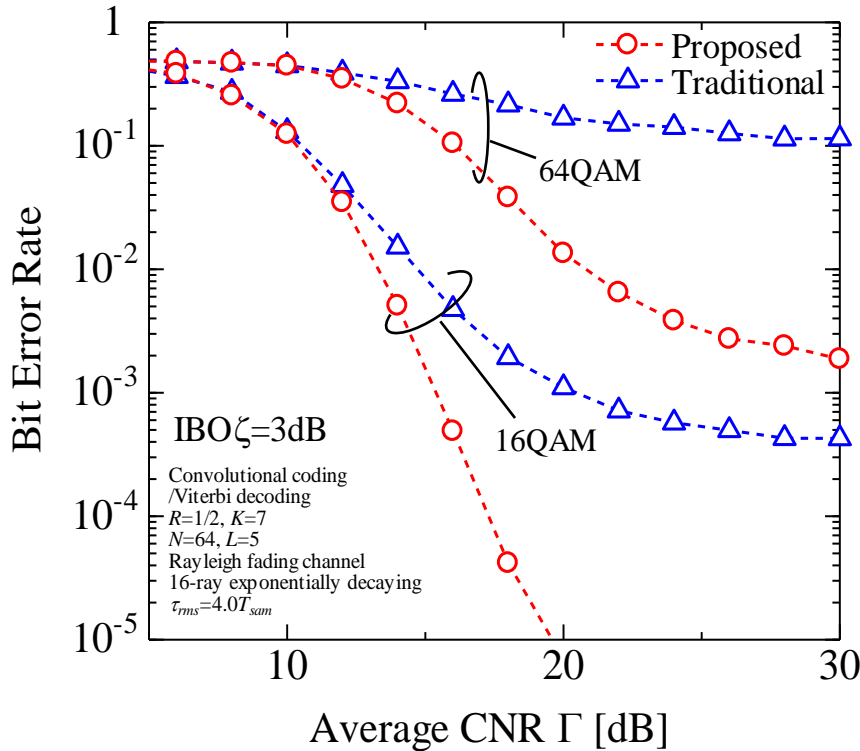


(a) Frequency spectrum

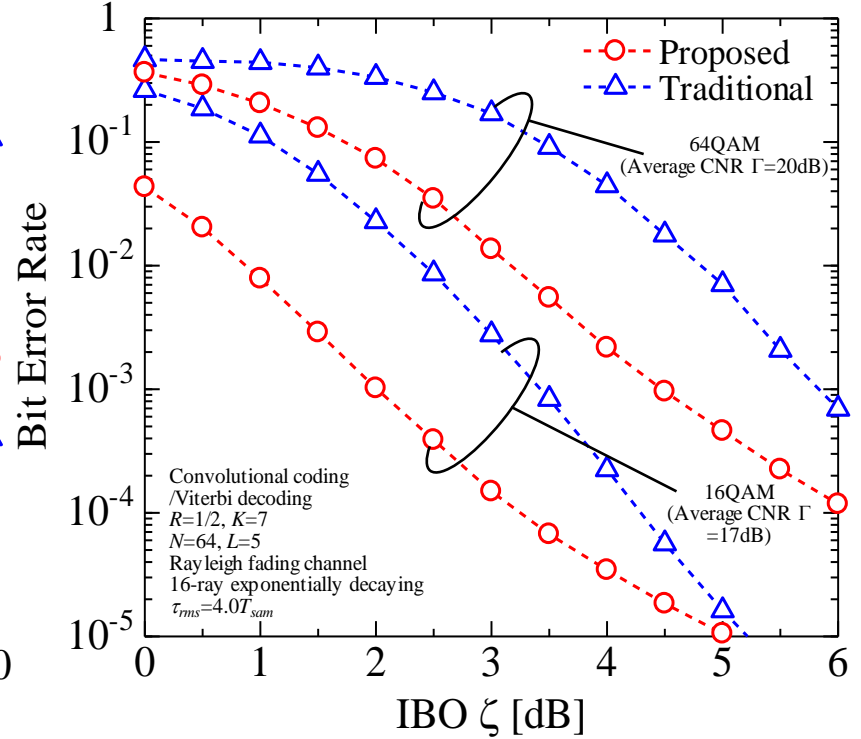
- The proposed and traditional methods significantly reduce the out-of-band radiation comparing with the case without clipping and filtering.

- The proposed and traditional methods generate nearly the same frequency spectrum.

BER performance



(a) BER performance versus average CNR



(b) BER performance versus IBO

The proposed method provides better BER than the traditional method regardless of the modulation scheme.

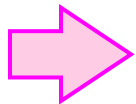
⇒ The transmit power control in the proposed method alleviates effectively the nonlinear distortion caused by clipping and filtering while the traditional method destroys the transmit OFDM signals instead of suppressing the out-of-band radiation.

Conclusion

We have proposed the OFDM clipping and filtering method using transmit power control to overcome the nonlinear distortion caused by the HPA.

Conclusion

- The proposed and traditional methods generate nearly the same frequency spectrum, which implies that the proposed method satisfies the good suppression performance in terms of the out-of-band radiation.
- The proposed method provides better BER than the traditional scheme regardless of the modulation scheme.



The proposed method achieves the improvement of the BER as well as the suppression of the out-of-band radiation.

