Software and Systems Engineering

CPE3202

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Introduction

➢ **High data rate transmission**
➢ **Robustness to multi-path fading**
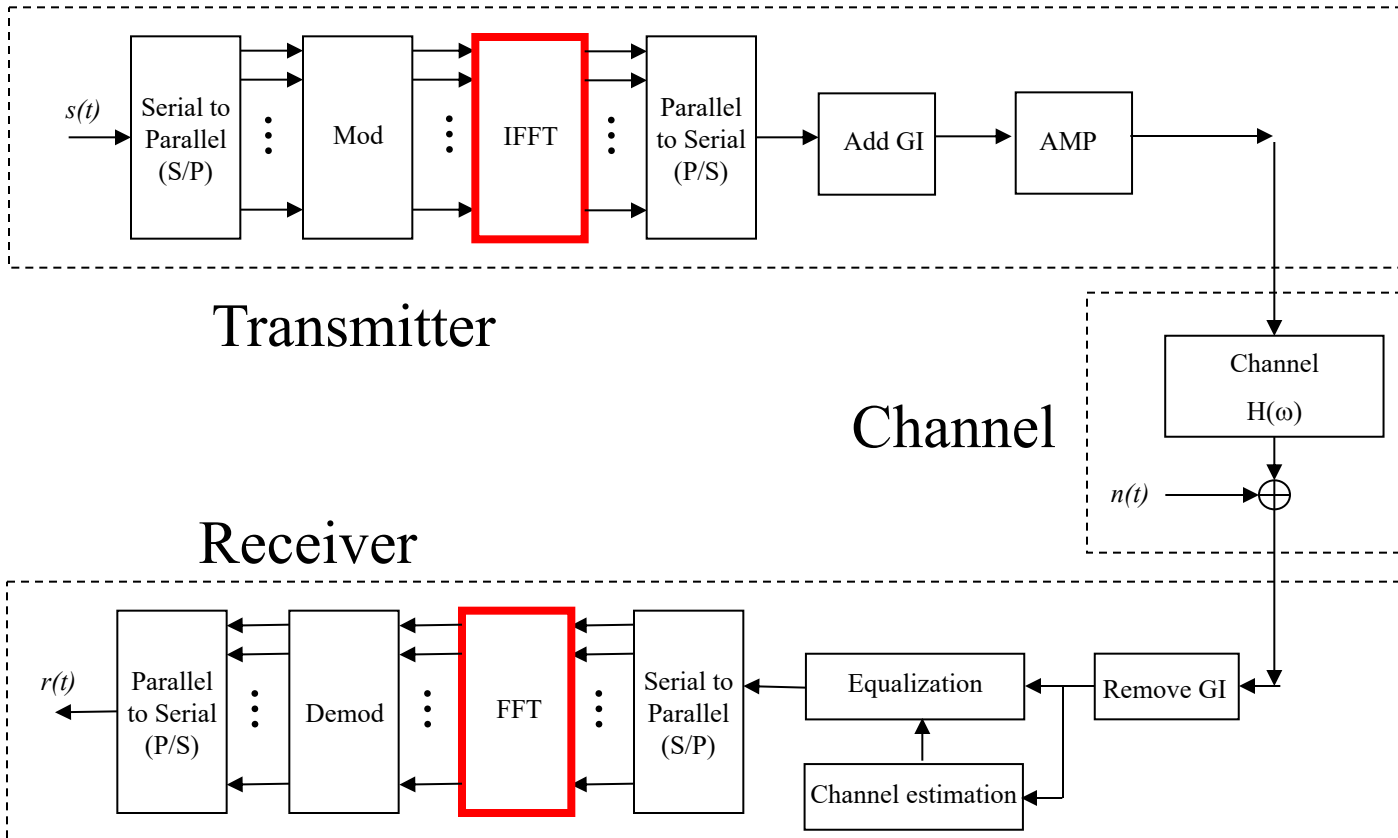➢ **Efficient usage of frequency bandwidth**

ADSL

Wireless LAN

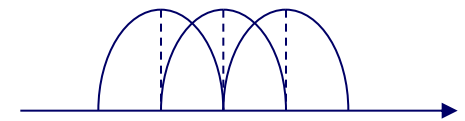**Terrestrial Digital TV**

Wireless system

Introduction

Orthogonal Frequency Division Multiplexing

System Overview

Transmitter

Channel

Receiver
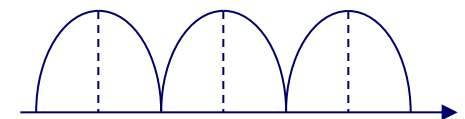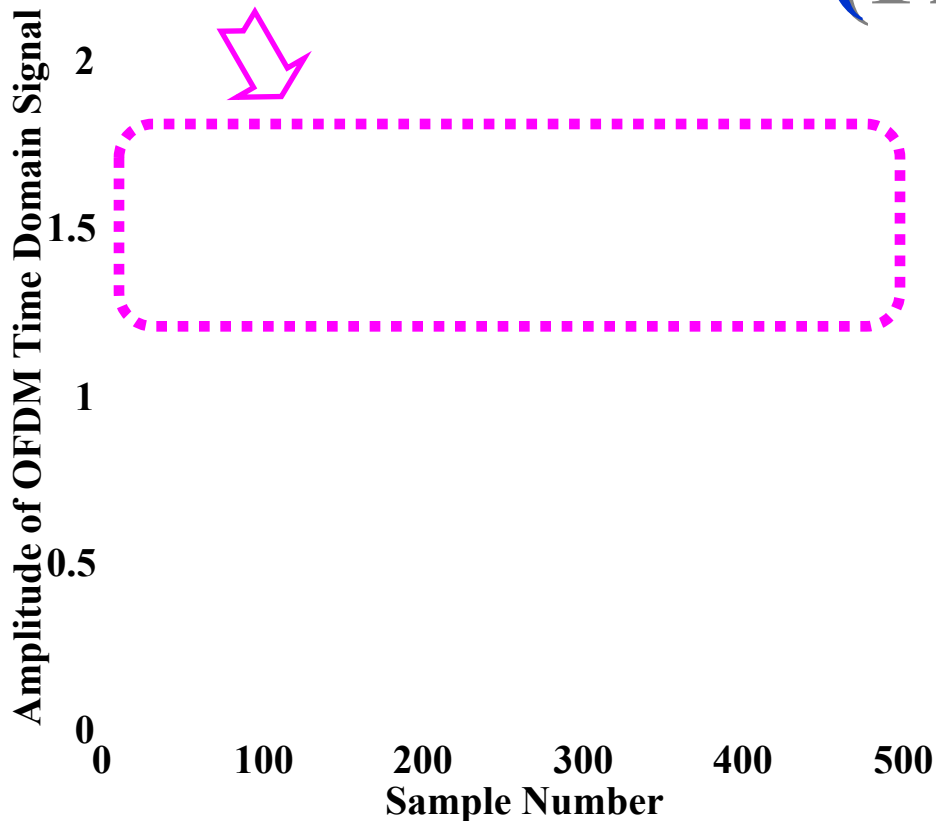
(a) OFDM spectrum

vs.

(b) conventional FDM spectrum
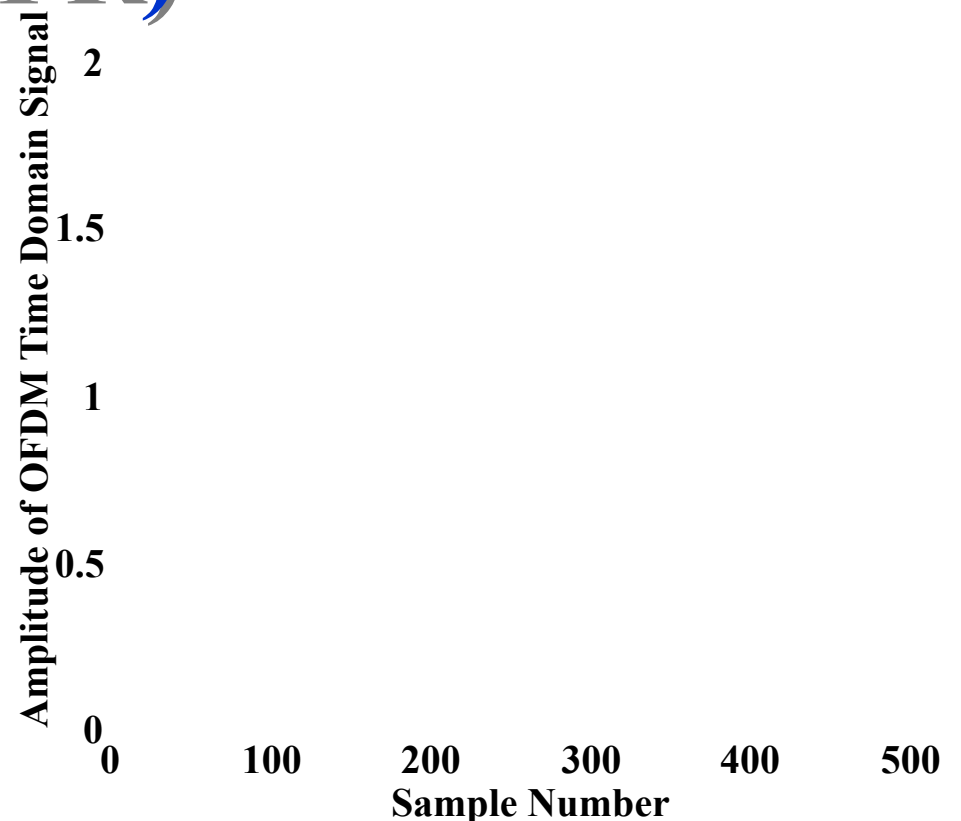
High Peak-to-Average Power Ratio (PAPR)

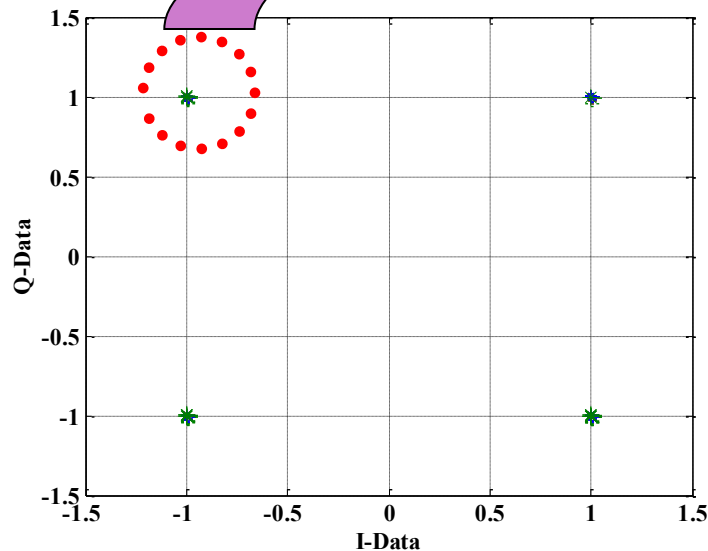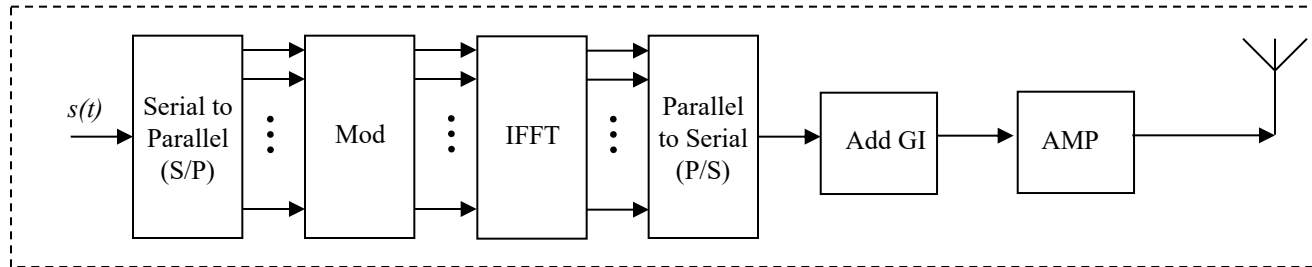(a) OFDM   carrier signals in time domain
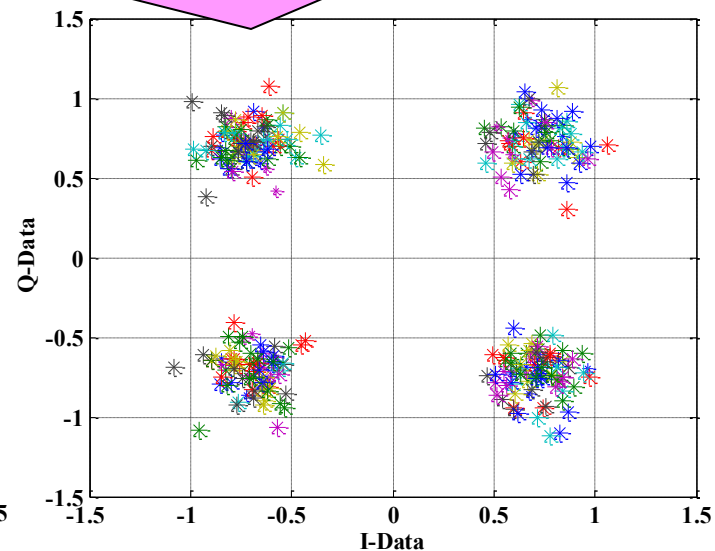
(b)   Single carrier signals in time domain

Introduction

Inter-Modulation Noise

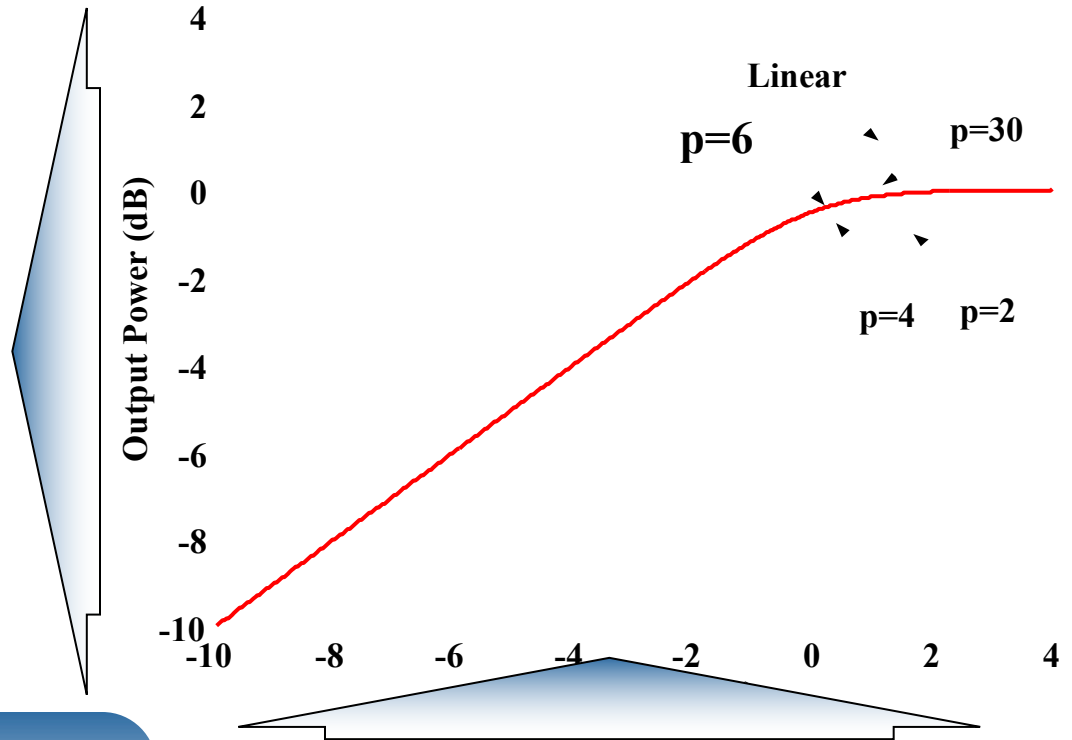Transmitter structure of conventional OFDM

(a) Original OFDM signal

(b) Output of power amplifier
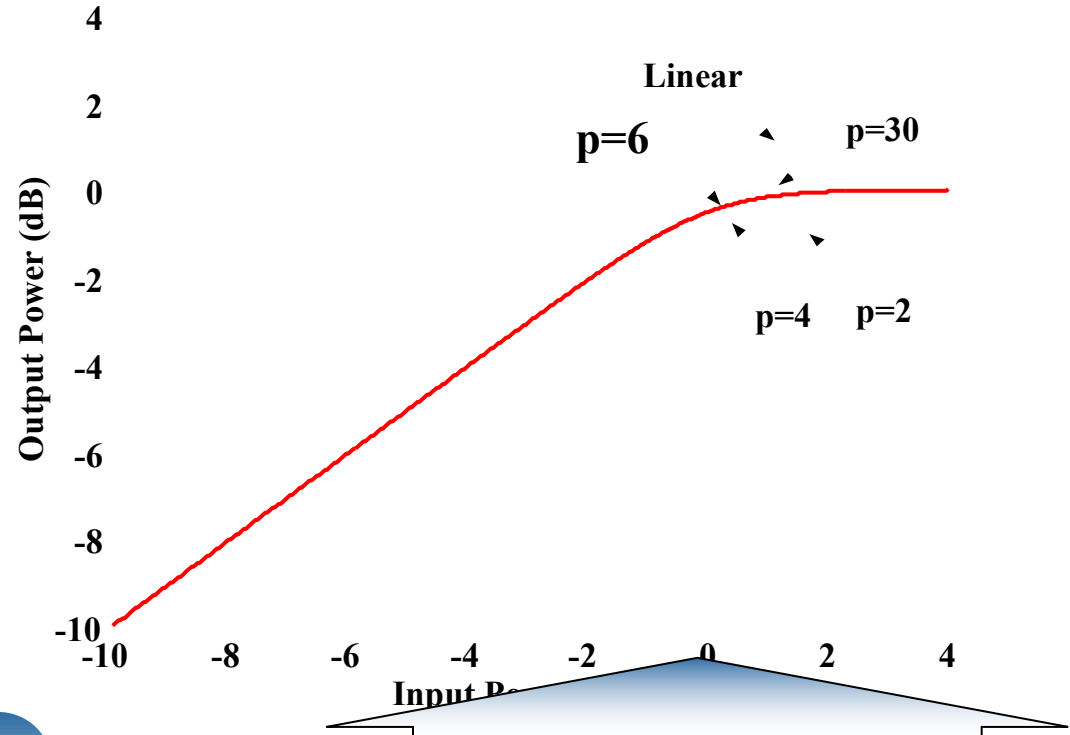
Introduction

Operation in Non-Linear Channel

$$z_k = F[|y_k|]e^{j\{\arg(y_k)+\Phi(|y_k|)\}}$$

where F[ ] and F[ ] represent the AM/AM and AM/PM conversion characteristics of non-linear amplifier.

Introduction

Operation in Non-Linear Channel

Inter-modulation Noise

Linear

p=6   **p=30**

p=4   **p=2**

Output Power (dB)

4

2

0

-2

-4

-6

-8

-10

-10   -8   -6   -4   -2   0   2   4

Input P...
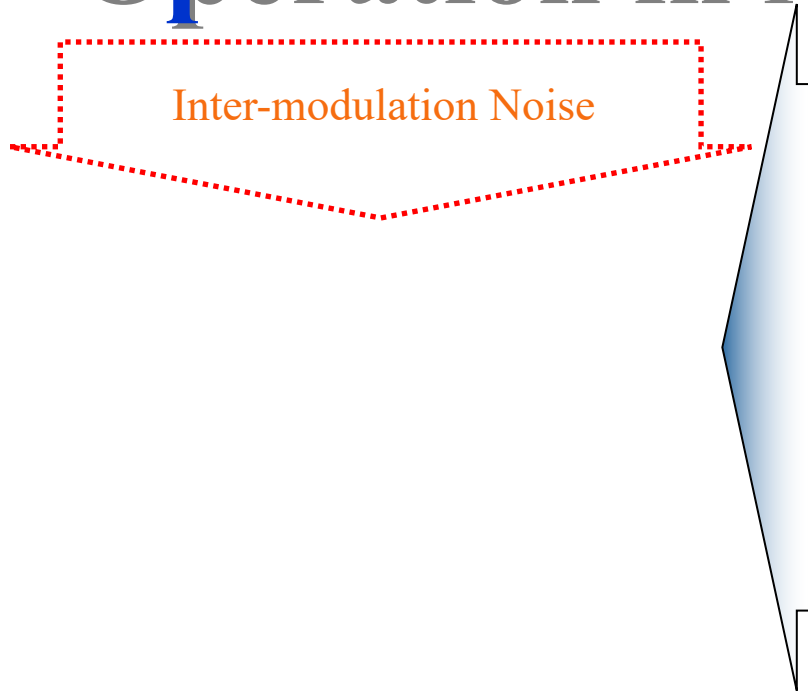
$$z_k = F[|y_k|]e^{j\{\arg(y_k)+\Phi(|y_k|)\}}$$

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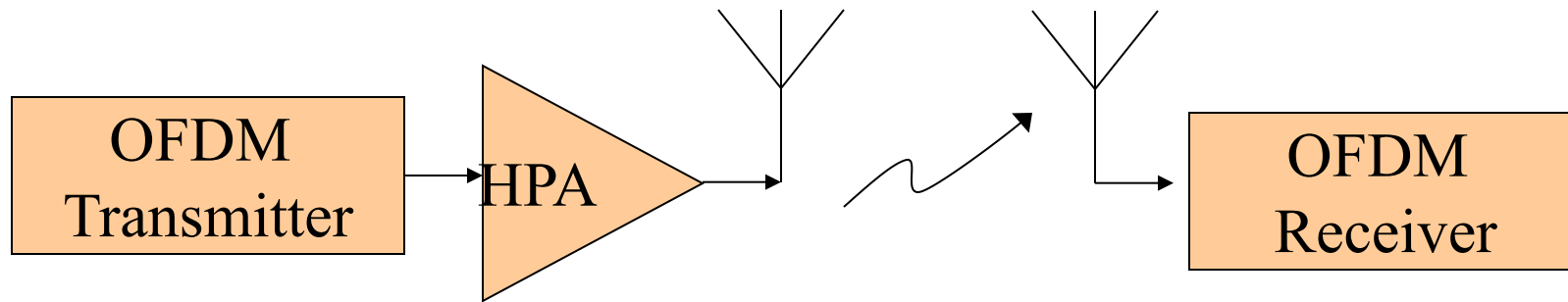
Introduction

Problems for Large IBO:

- **Low signal power.**
- **Inefficient of using HPA.**
- **Cost battery life for mobile terminals.**

Problems for Small IBO:

- **Spectrum re-growth.**
- **Degrades the BER performance.**

Introduction

**Allocation for Mitigation methods of non-linear distortion**

Inter-Modulation Noise Mitigation Method

❑ **The clipping method can achieve efficient usage of non-linear amplifier and smaller spectrum re-growth but it will cause the degradation of BER performance at the receiver due to clipping noise.**

❑ **Decision Aided Reconstruction (DAR) method can mitigate the clipping noise and can improve BER performance by re-constructing the clipping noise at the receiver.**

❑ **DAR Method can not mitigate the inter-modulation noise due to non-linear amplifier.**

❑ **Proposed IDAR method can mitigate both clipping and inter-modulation noises.**

OFDM Transmitter with Clipping Method
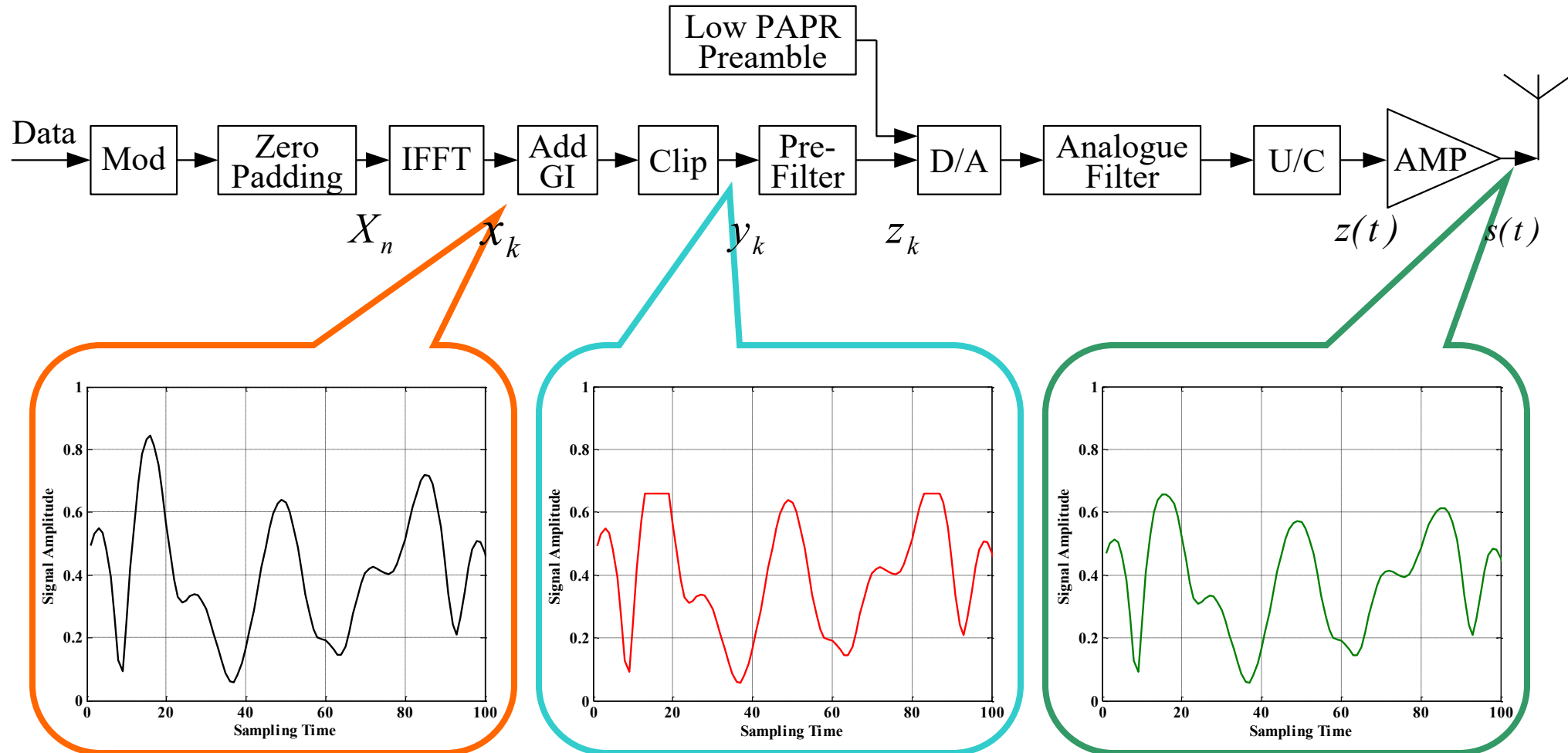
Basic concept of DAR method
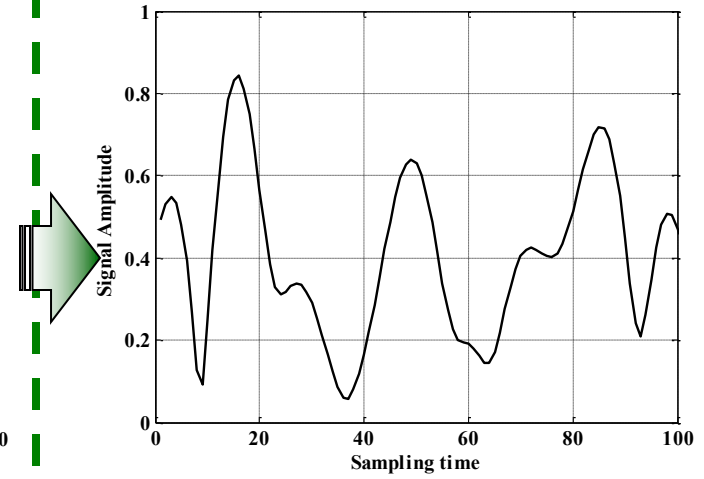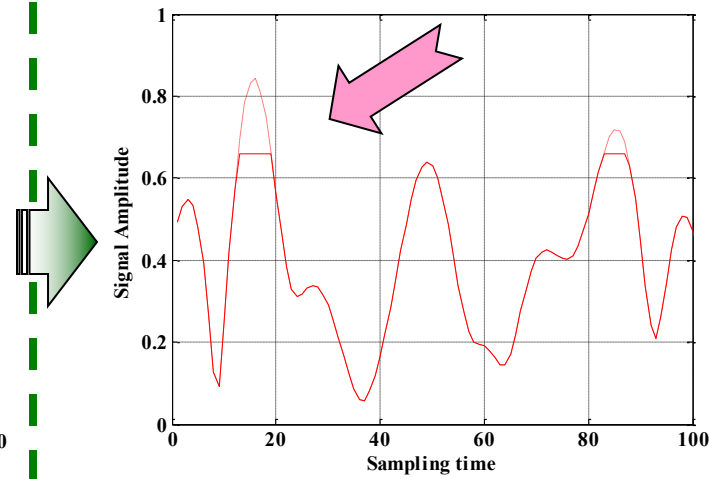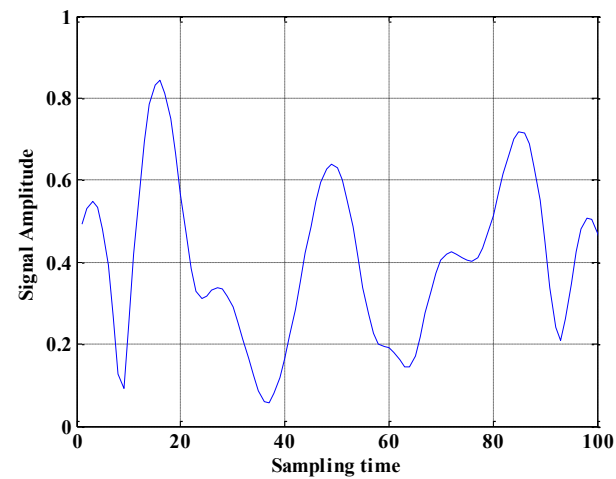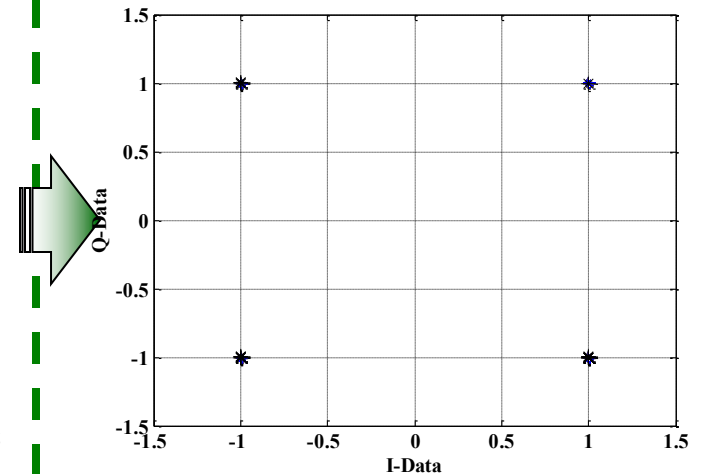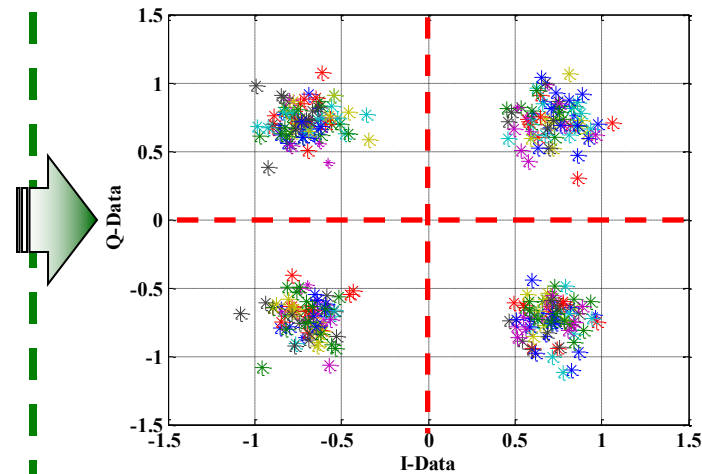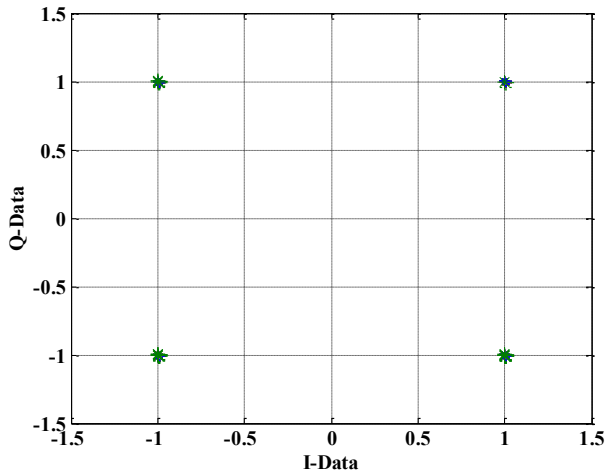
OFDM signal

Clipped signal

Reconstructed signal

Structure of DAR and IDAR method

IDAR method Employment in the Satellite Channel.
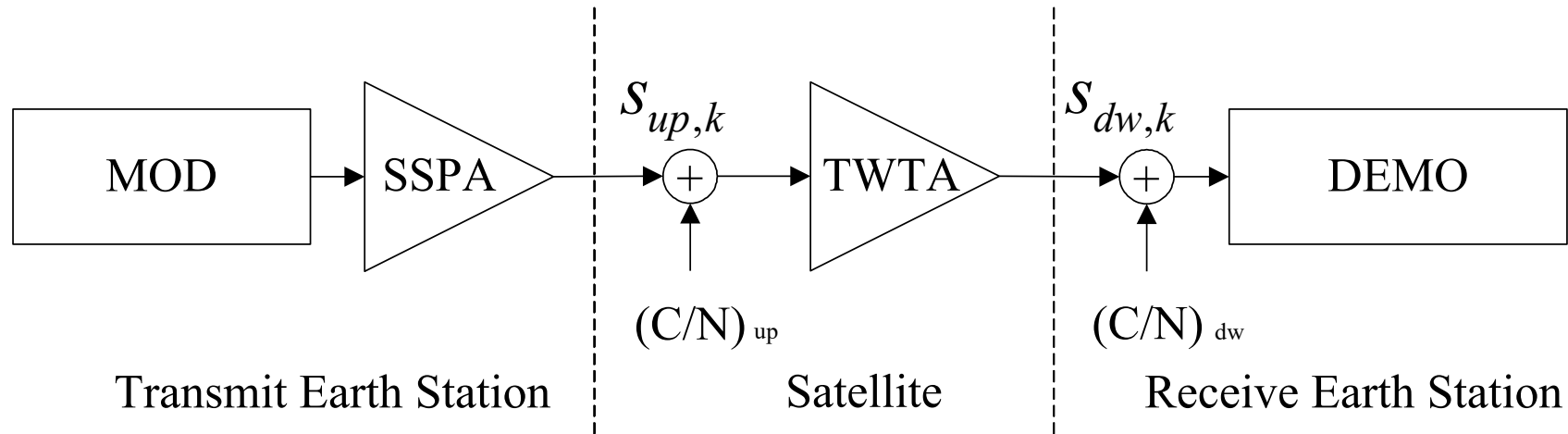
MOD → SSPA → $S_{up,k}$ ⊕ → TWTA → $S_{dw,k}$ ⊕ → DEMO

$(C/N)_{up}$

$(C/N)_{dw}$

Transmit Earth Station | Satellite | Receive Earth Station

There are two non-linear amplifiers located both at earth station and satellite transmitters.

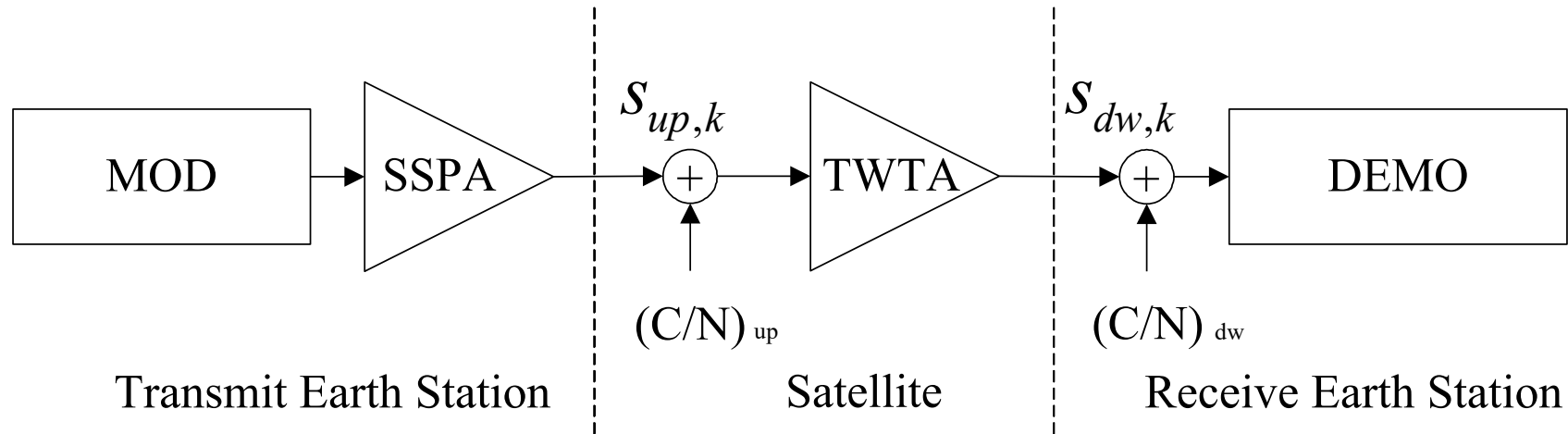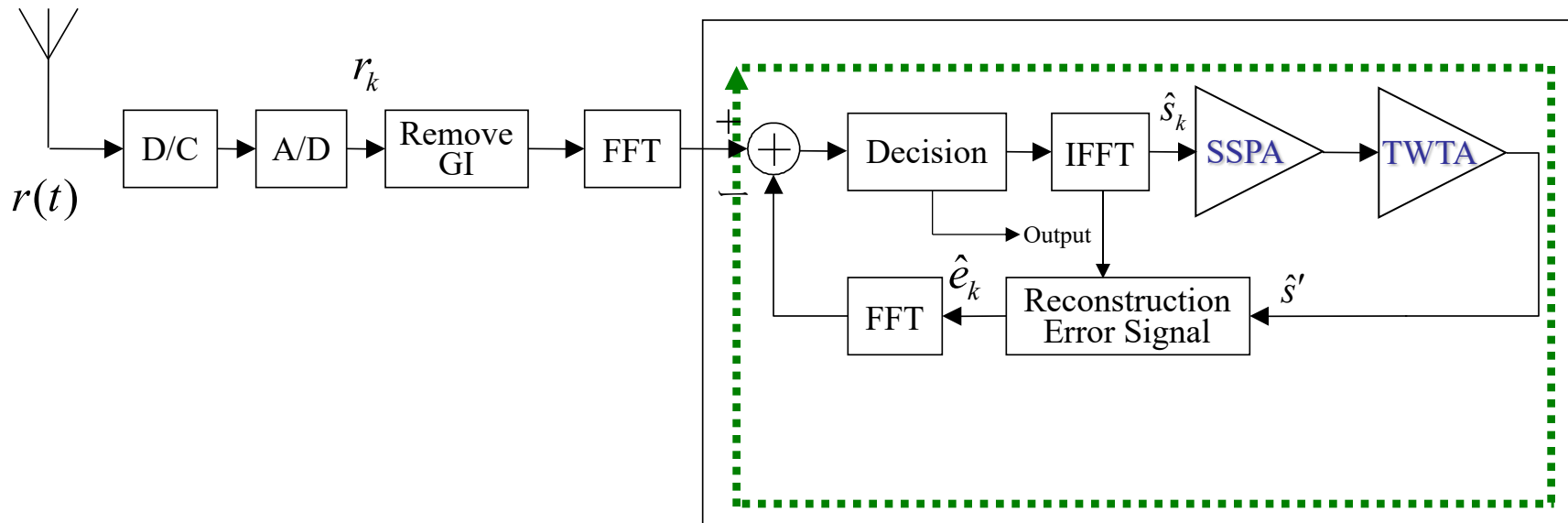**Model of satellite communication systems**

IDAR method Employment in the Satellite Channel.

There are two non-linear amplifiers located both at earth station and satellite transmitters.

Model of satellite communication systems

IDAR method Employment in the Satellite Channel.

Structure of receiver with IDAR method designed for the Satellite channel

Non-linear Amplifier Characteristics Estimation Method

❑ **IDAR requires for input and output relationships of AMP, which includes AM-AM and AM-PM conversions characteristics.**

❑ **Estimation of AM-AM and AM-PM conversions characteristics are also required to update at the receiver frequently to cope with the changing**
  - of characteristics of AMP due to operation environments
  - of actual operation point (IBO: Input Back off) of satellite TWTA due to rain attenuation.

Estimation Method for Non-Linear Amplifier Characteristics

Average power of OFDM signal in the time domain
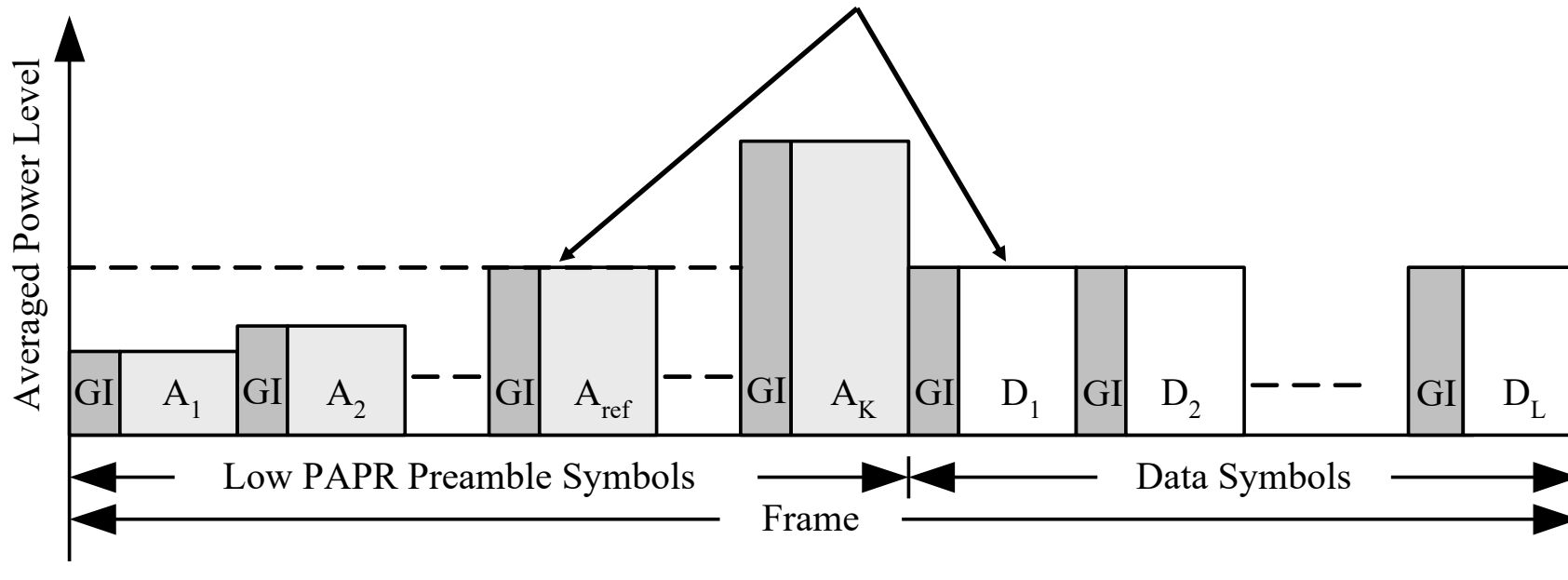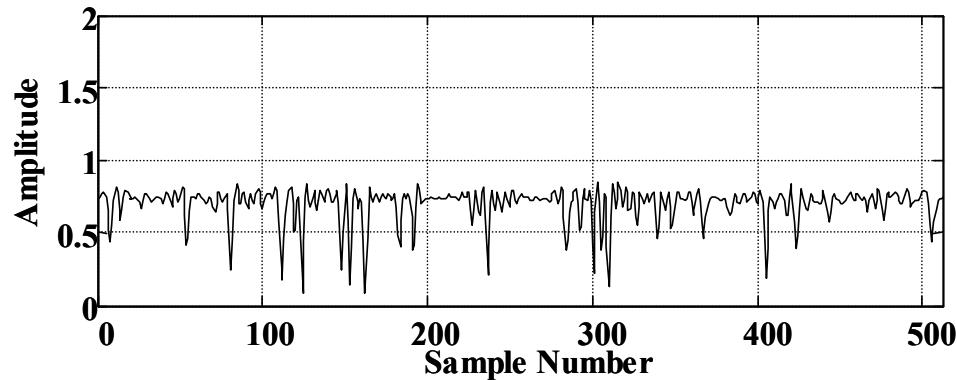
Structure of proposed frame format

Proposal of Estimation Method for Non-Linear Amplifier Characteristics
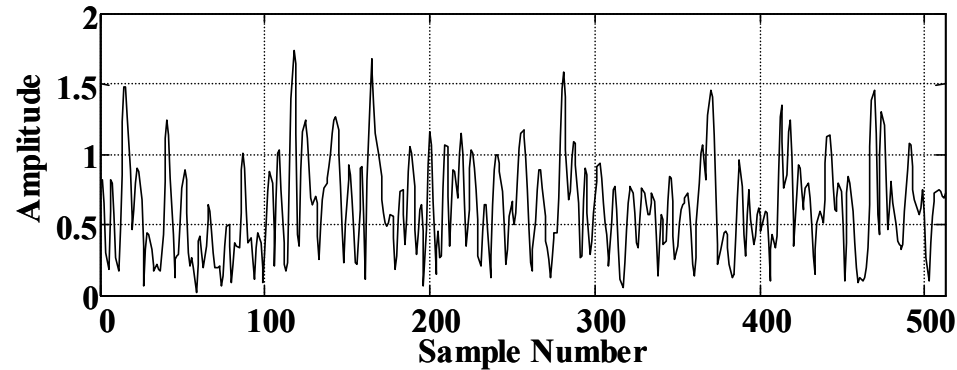
(a) Conventional preamble symbol

(b) Low PAPR preamble symbol

The time-frequency domain-swapping is employed for the generation of low PAPR preamble symbol.

Envelope of preamble symbol in time domain.

Estimation Method
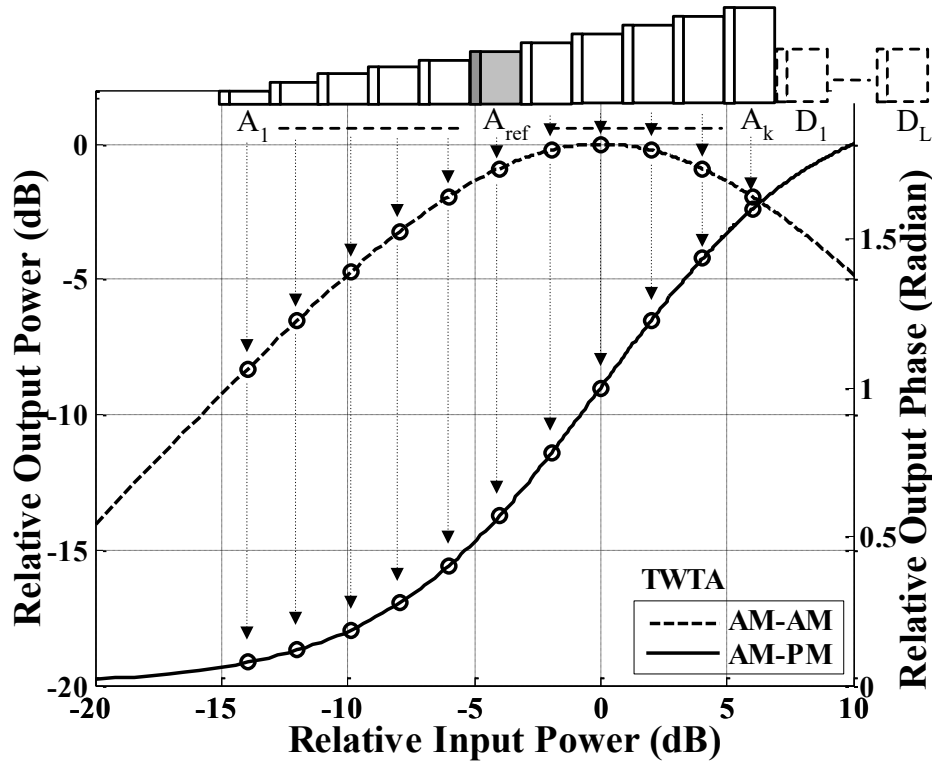
(a) Actual input and output relationships of non-linear amplifier.
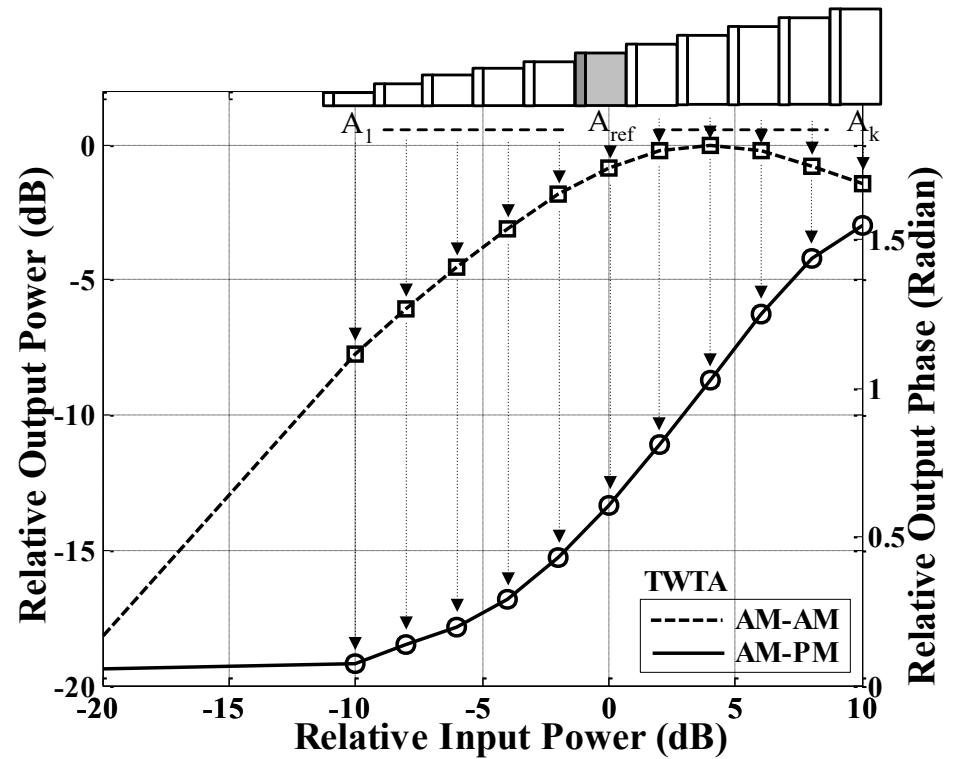
(b) Estimated input and output relationships of non-linear amplifier.

Simulation results of Proposed Method

BER performance versus downlink C/N when TWTA IBO is selected by optimum value

Combination Between PAPR Reduction and Inter-Modulation Noise Mitigation Method
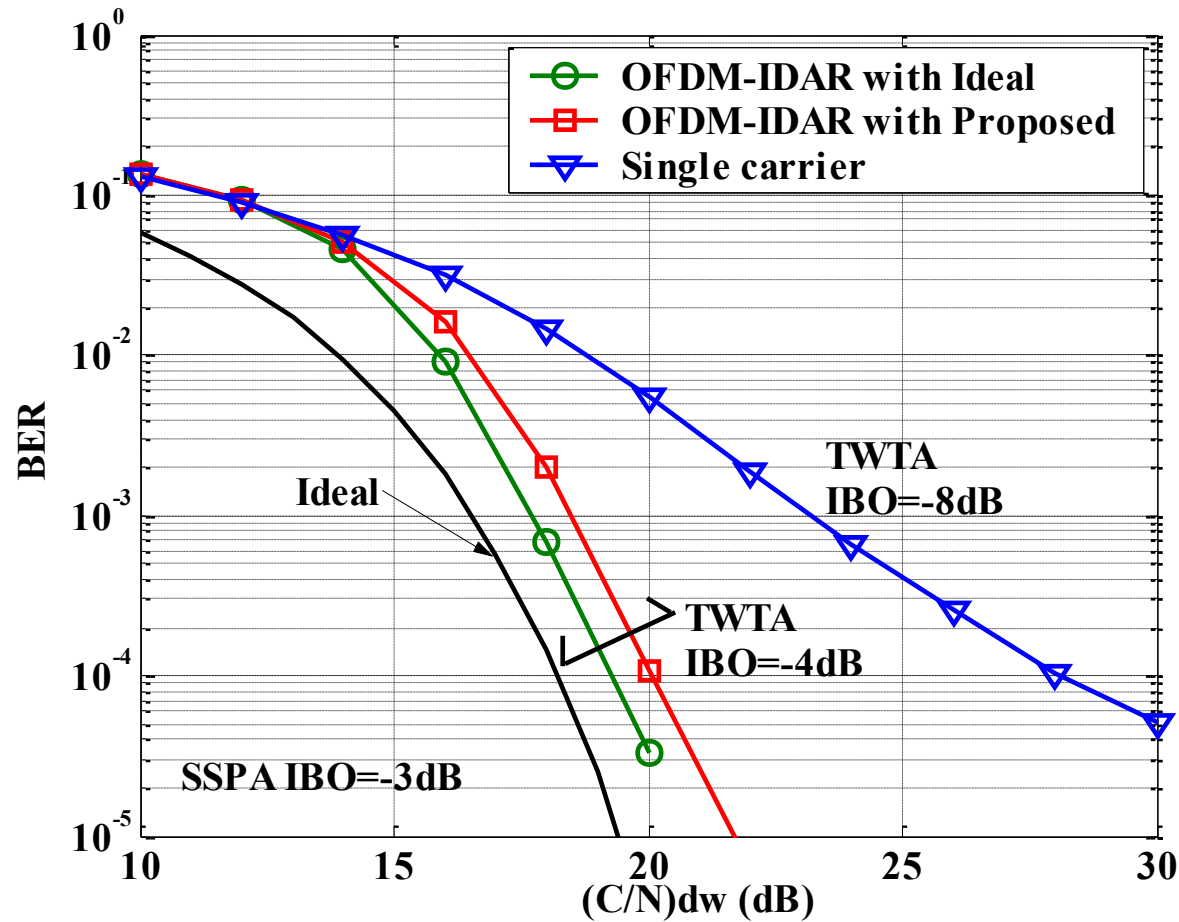
❑ **The future communications systems are required to support the higher transmission data rate for providing the multimedia services**

❑ **Multi-level QAM have capability to increase transmission data rate.**

❑ **However, the proposed OFDM-IDAR method has some limitation of usage for higher level of modulation method such 64QAM.**

❑ **To reduce the non-linear distortion, it is required to improve the PAPR performance as much as possible for the transmission OFDM signal.**

Combination Between PAPR Reduction and Inter-Modulation Noise Mitigation Method

❑ **If the PAPR performance can be improved somehow for the transmission signal, the non-linear distortion can be also reduced and IDAR method could work well.**

❑ **Combined with PTS Method, it can achieve the better PAPR performance with less complexity when compared with SLM method but required side information.**

❑ **Combined with DSI method, it has simple system because the side information is no required.**

Simulation results of IDAR Method
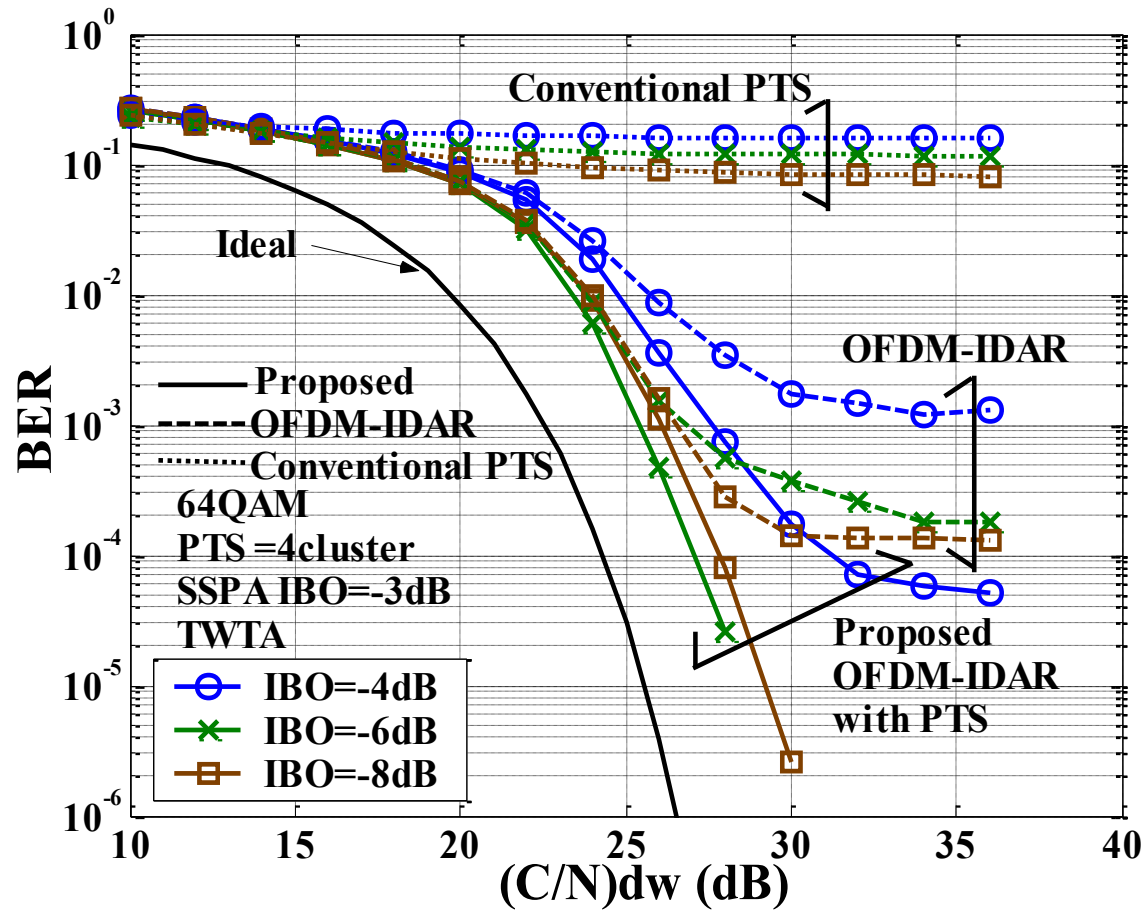
BER performance versus downlink C/N (PTS with IDAR-OFDM)

Simulation results of IDAR Method
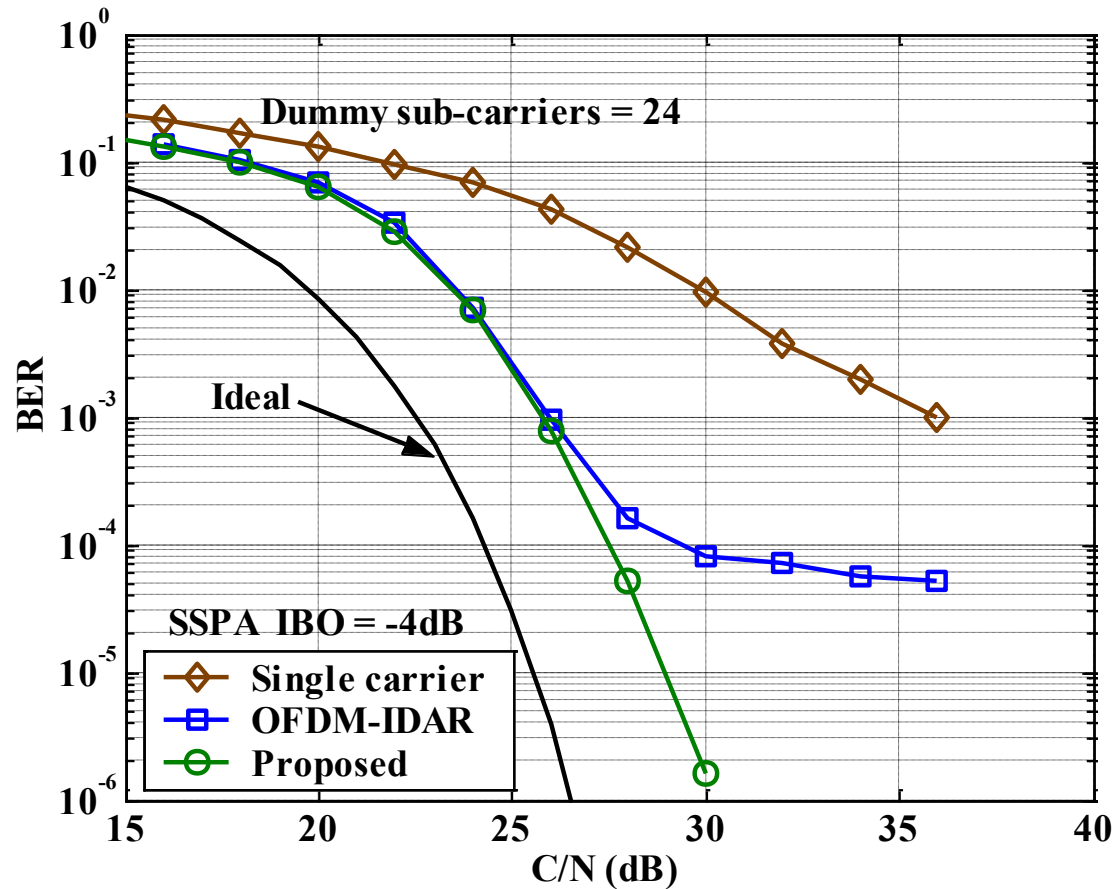
BER performance versus downlink C/N (DSI with IDAR-OFDM)

Conclusions

❑ **The IDAR method can efficiently mitigate the clipping and inter-modulation noise mitigation method in the WLAN and satellite channels.**

❑ **non-linear amplifier estimation method for IDAR method.**

❑ **The PAPR reduction conjunction with the inter-modulation noise mitigation method, can efficiently use the high multi-level QAM such as 64QAM.**