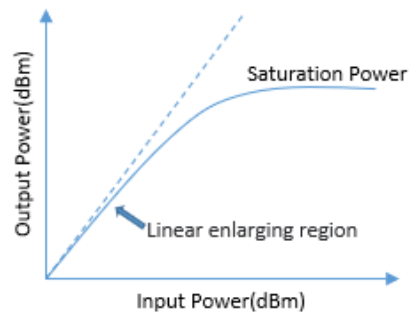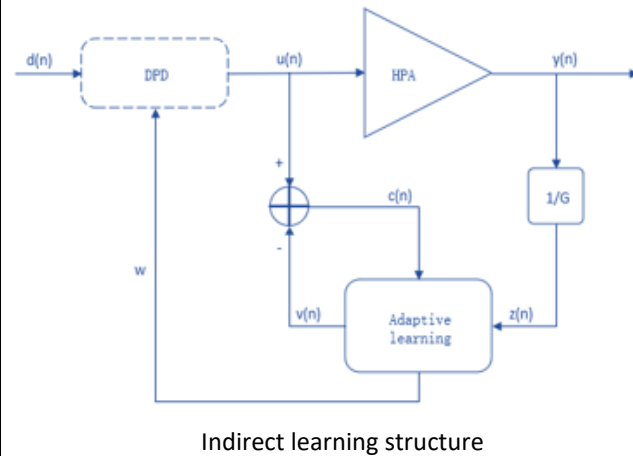## Introduction of the Power Amplifier

- The gain of the power amplifier is constant ideally.
- Actually there is only a small linearly amplified region.
- Requirements of PA for modern modulation are higher and higher.

Power amplifier characteristic curve

Problems and Purpose

When the peak-to-average ratio signal like OFDM falls into the nonlinear amplification region, it will result in:
- In-band distortion
- Out-of-band spectrum spread

How to improve the linear amplification range of the power amplifier?

Digital Pre-distortion

Digital Predistortion Schematic

The purpose of DPD is to improve the linearity. From the point of view of mathematical model, the pre-distorter can be regarded as the inverse model, and the characteristics are opposite to that of the PA.

Specific operation:
- Find the inverse model of PA by adaptive learning
- Compensate the distortion by DPD before the signal passes through the PA

Adaptive learning structure

Indirect learning structure

There is a process of feedback and learning to obtain the characteristic curve of the pre-distorter.

There are two common structures:

1) direct learning

2) indirect learning

Compared with direct learning, indirect learning does not require pre-estimation of the PA model, so the adaptive ability is stronger.

Learning algorithms

- LMS:
  low complexity
  slow convergence
- RLS:
  high complexity
  fast convergence
  high precision
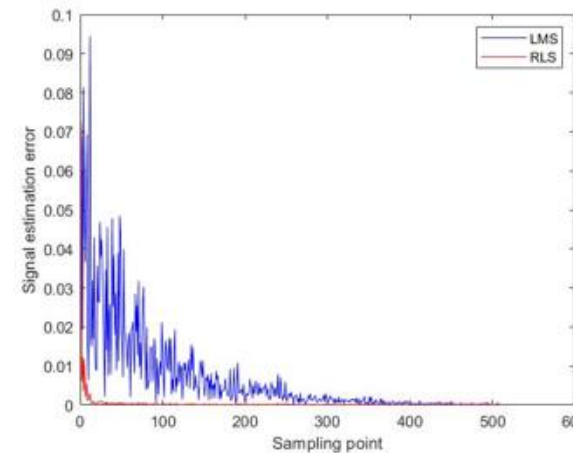
Estimation error

The true coefficient:
H = [-0.1 0.2 0.7 0.4 -0.2 -0.1 0.12 -0.25]

LMS estimated	RLS estimated
-0.0999	-0.1000
0.2000	0.2000
0.7000	0.7000
0.4000	0.4000
-0.1999	-0.2000
-0.1000	-0.1000
0.1200	0.1200
-0.2500	-0.2500

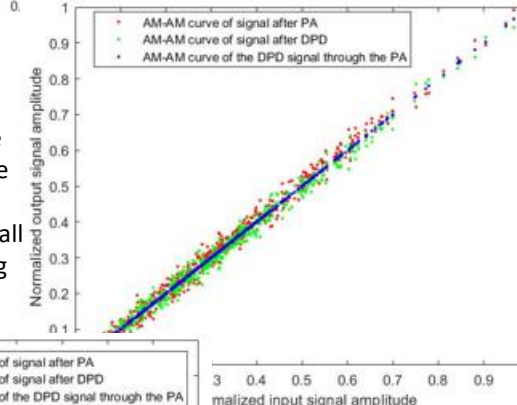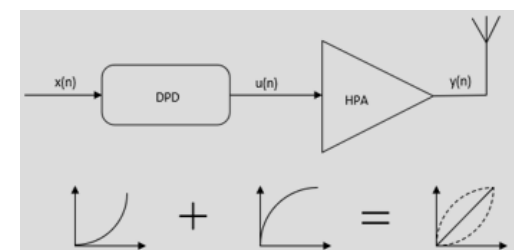Algorithm verification

Model simulation

Parameter settings

PA Model	Memory polynomial model
Modulation	QPSK
Number of subcarriers	512
Adaptive Algotithm	RLS
Parameter δ	0.01
Parameter λ	1
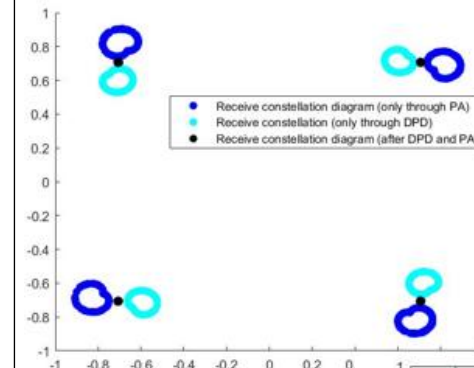
The output of the PA and the output constellation points of the DPD are obviously centrosymmetric about the undistorted point, which shows that the distortion characteristics of them are just opposite.

Conclusion

It can be seen from the picture that the amplitude and phase distortion of the signal introduced by the nonlinearity of the PA are all compensated after passing through the DPD.

This is equivalent to expanding the linear amplification range of the PA and avoiding the loss of energy efficiency due to power back-off.