

# 適應性盲蔽決策回饋等化器

## Adaptive Blind Decision Feedback Equalizers

指導老師：袁正泰 老師 指導學長：張維傑 專題生：鍾詩緯、李繼衡、紀昌佑  
輔仁大學 電機工程學系 大學部專題生

### Abstract

- This report proposes three adaptive blind decision feedback equalizers (DFEs) which are able to deal with the problems of inter-symbol interference (ISI) and carrier phase offset (CPO).
- The first DFE uses the blind equalizer employing the constant modulus algorithm (CMA) followed by the phase rotator (PR). The second DFE uses the blind equalizer employing the constant modulus algorithm (CMA) followed by the phase tracker (PT). The third DFE used the blind equalizer employing the multimodulus algorithm (MMA).
- Computer simulations were conducted to compare the performances of the three adaptive blind DFEs.

### Introduction

- Digital communications exhibit the inter-symbol interference (ISI) and the carrier phase offset (CPO) owing to multiple transmitted paths and the mismatch between the transmitter and receiver oscillators, respectively. The CPO includes both the normalized carrier frequency offset and the fixed phase offset.
- The adaptive blind DFE [1] is composed of gain control (GC), the Zero-Pole Whitening Filter (ZPWF), the blind equalizer (BE). The equalizer adopted the two-mode scheme (i.e., starting mode and tracking mode) [2] to mitigate the error propagation. However, this equalizer only can deal with the effect of the ISI.
- Therefore, we propose three novel adaptive blind DFEs which are able to deal with the ISI as well as the CPO, including the ZPWF-CMA-PR, the ZPWF-CMA-PT and the ZPWF-MMA.

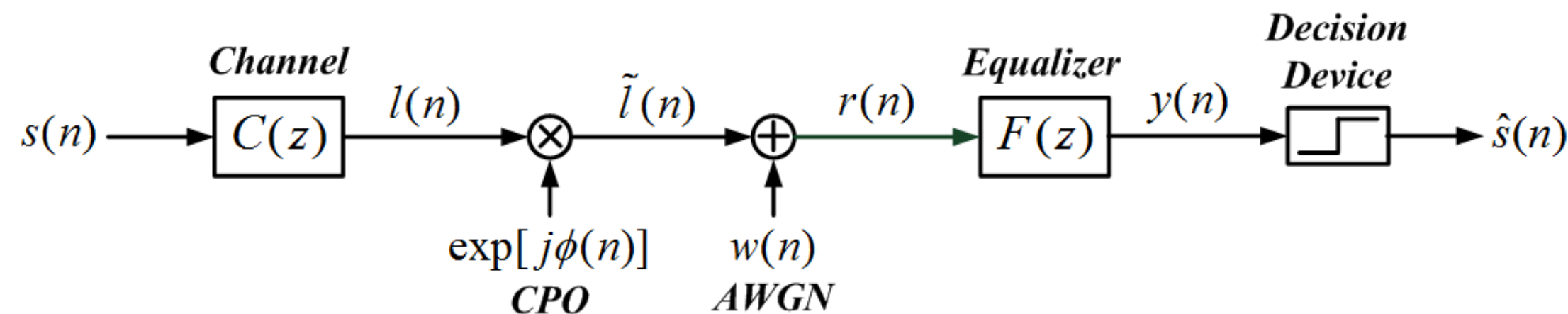


Fig. 1. Baseband model of a communication system.

### The Proposed ZPWF-CMA-PR

- The adaptive blind DFE followed by the phase rotator (PR), which is referred to herein as the ZPWF-CMA-PR.

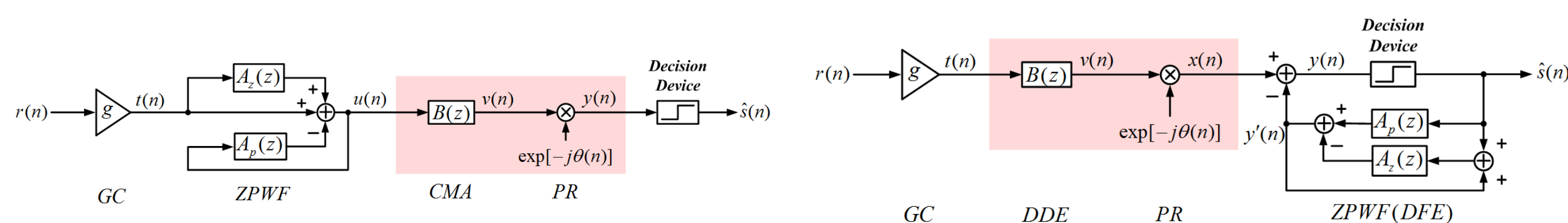


Fig. 2(a). Starting mode of ZPWF-CMA-PR.

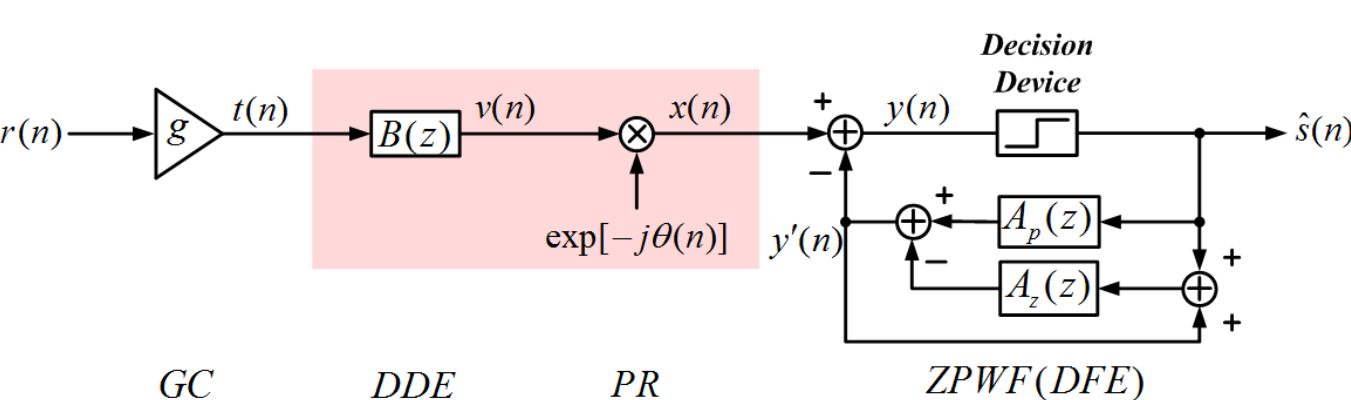


Fig. 2(b). Tracking mode of ZPWF-CMA-PR.

### The Proposed ZPWF-CMA-PT

- The adaptive blind DFE followed by the phase tracker (PT), which is referred to herein as the ZPWF-CMA-PT.

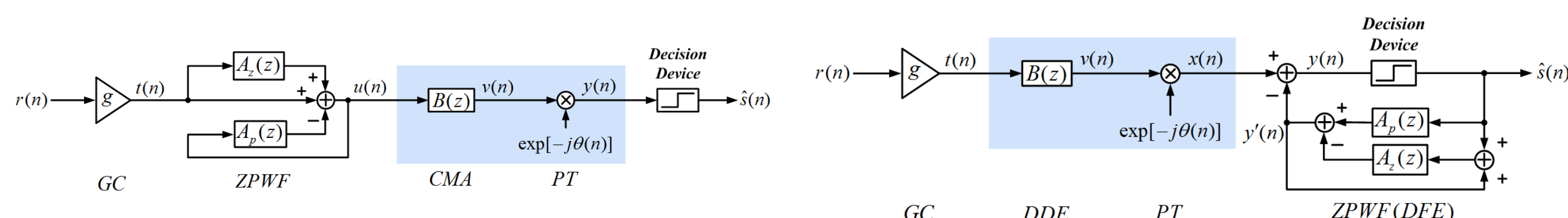


Fig. 3(a). Starting mode of ZPWF-CMA-PT.

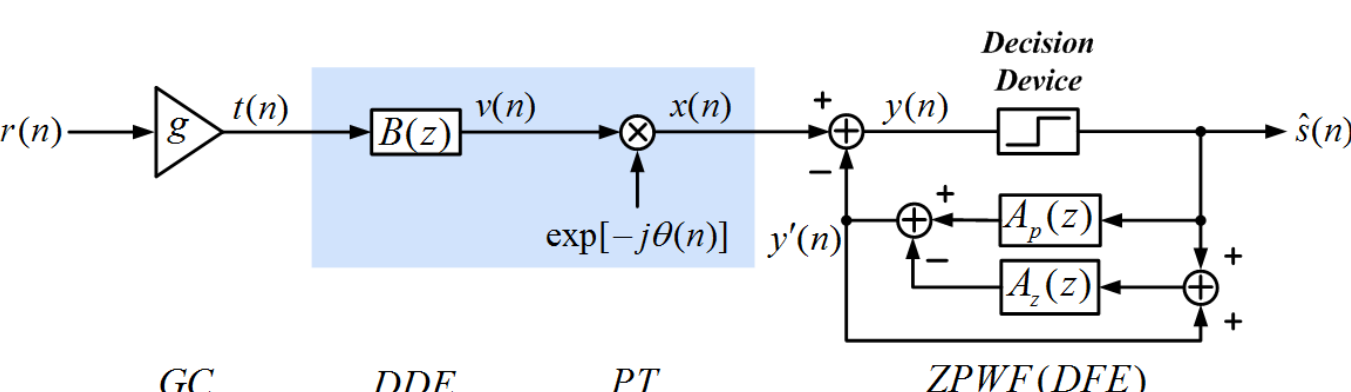


Fig. 3(b). Tracking mode of ZPWF-CMA-PT.

### The Proposed ZPWF-MMA

- The adaptive blind DFE in which the BE employs the MMA is referred to herein as the ZPWF-MMA.
- Since the MMA is a joint blind equalization and the carrier phase recovery algorithm, the MMA does not need a phase detector (e.g. the PT and the PR) to deal with the CPO problem.

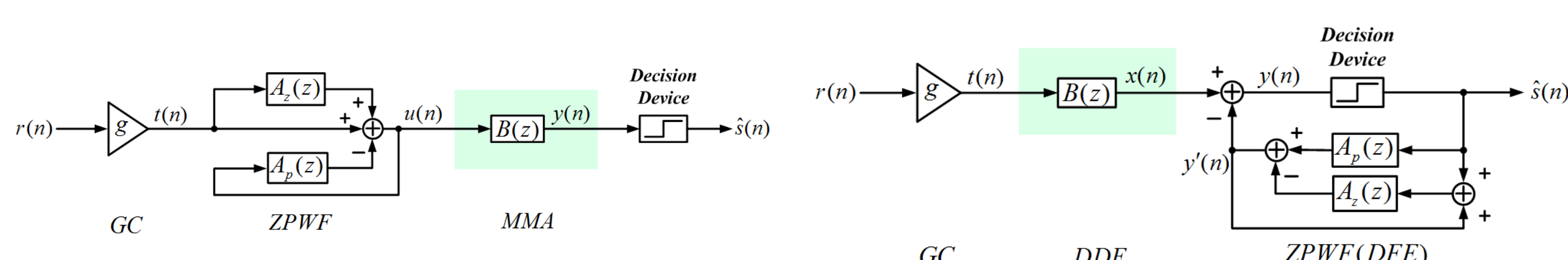


Fig. 4(a). Starting mode of ZPWF-MMA.

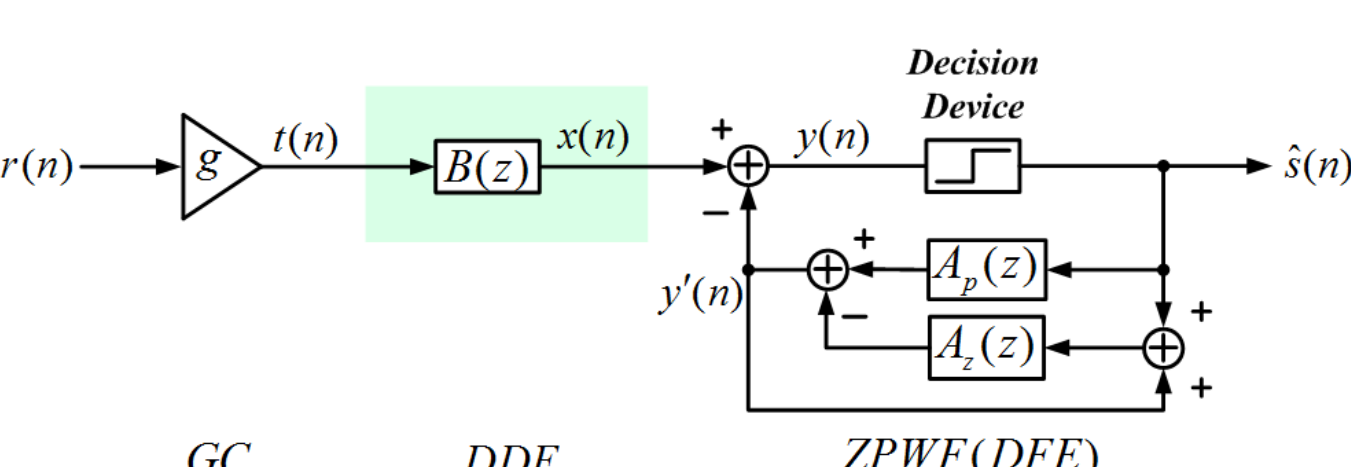


Fig. 4(b). Tracking mode of ZPWF-MMA.

### Computer Simulations

- Computer simulations were conducted to compare the performances among the ZPWF-CMA-PR, the ZPWF-CMA-PT and the ZPWF-MMA. The performance measure is based on ensemble-average mean-squared error (MSE) in dB over 100 independent runs. The signal constellations used in the simulations are 16-QAM and the signal-to-noise ratio (SNR) is 25 dB.
- Impulse response of the channel is

$$C(z) = 0.04 - 0.05z^{-1} + 0.07z^{-2} - 0.21z^{-3} - 0.5z^{-4} + 0.72z^{-5} + 0.36z^{-6} + 0.21z^{-8} + 0.03z^{-9} + 0.07z^{-10}$$

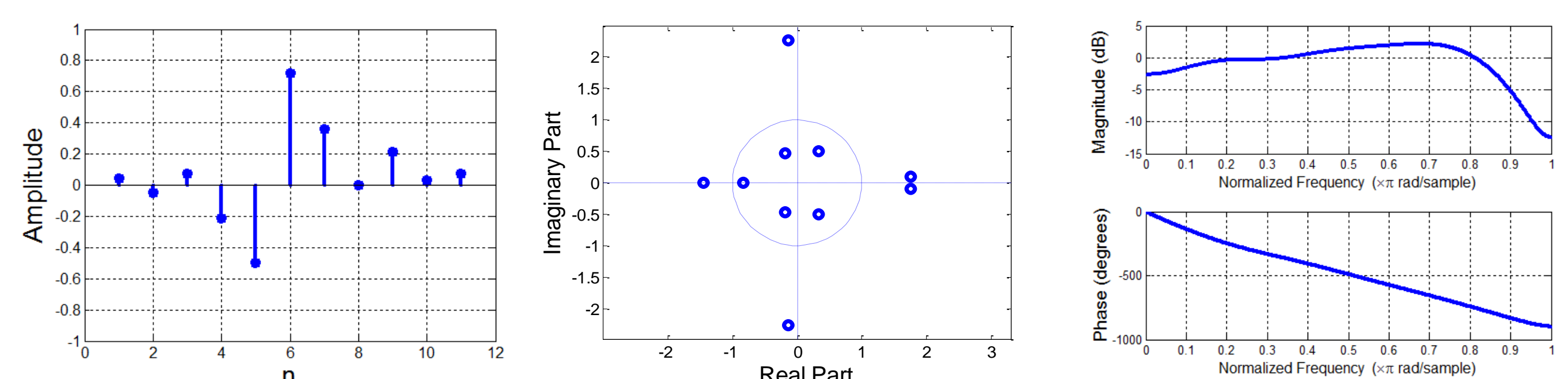


Fig. 5. (a) Impulse response of channel (b) Pole-zero diagram of channel. (c) Frequency responses of channel.

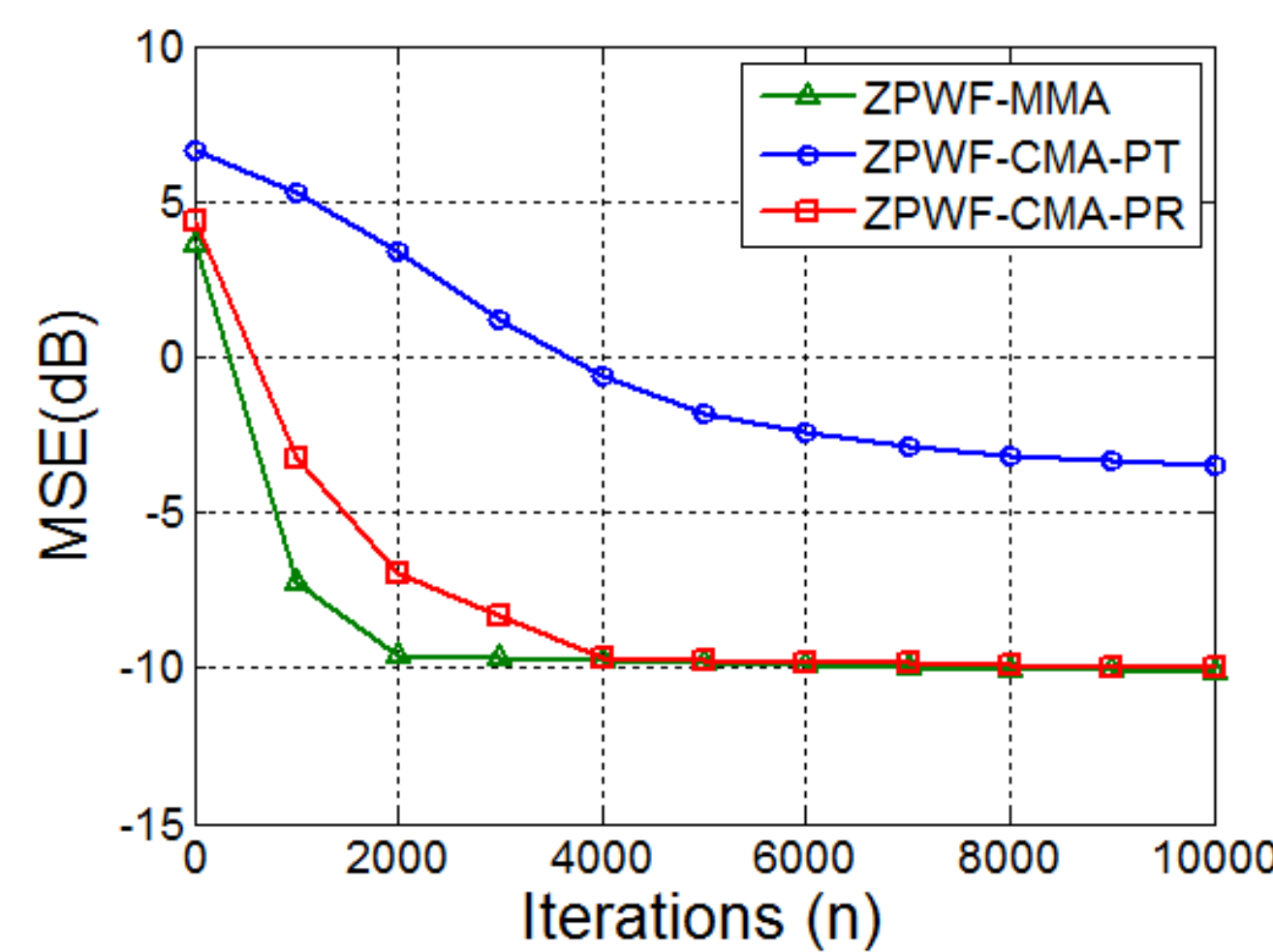


Fig. 6(a).  $\Delta f \cdot T = 1.5 \times 10^{-5}$ ,  $\phi_0 = 0^\circ$

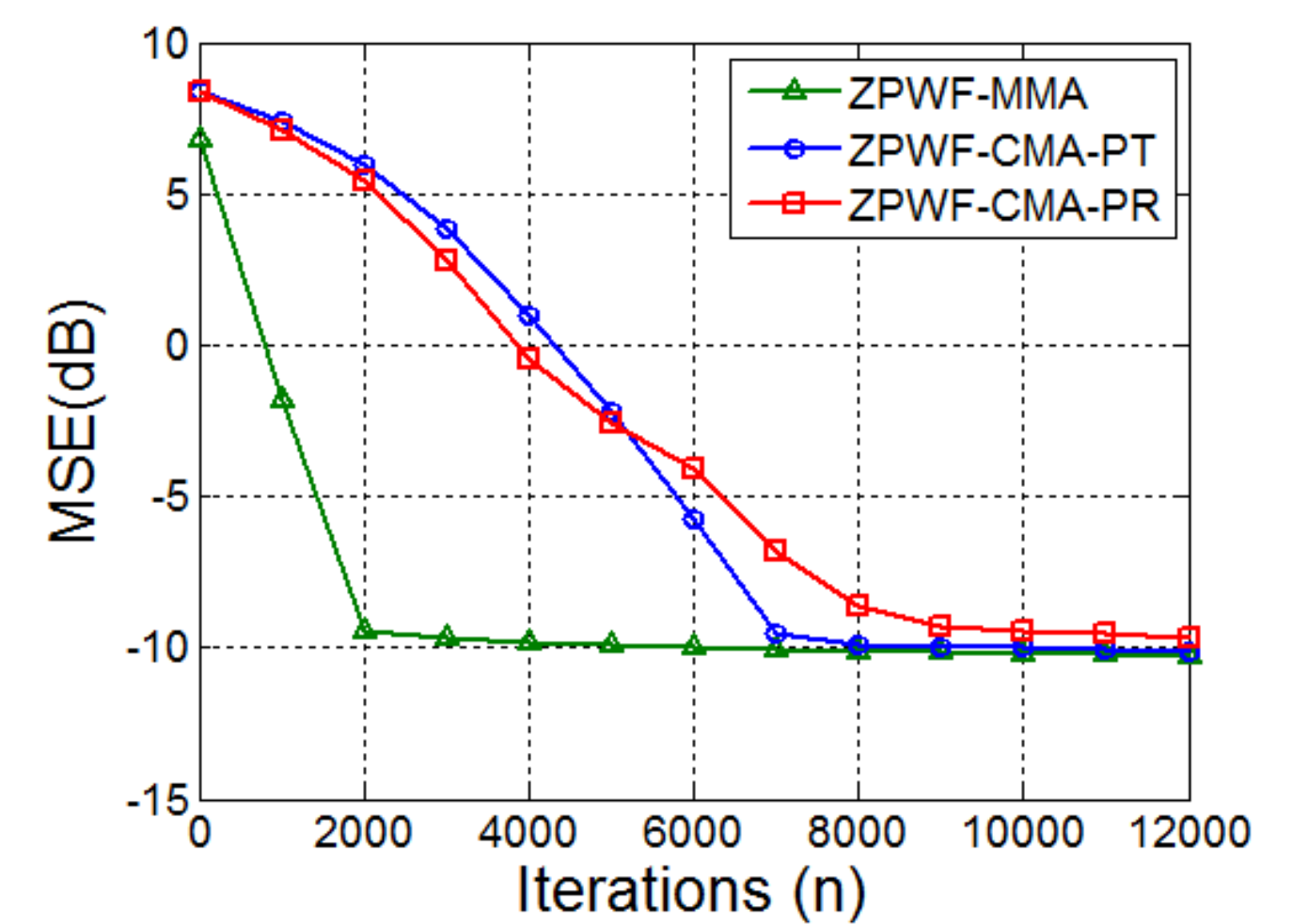


Fig. 6(b).  $\Delta f \cdot T = 0$ ,  $\phi_0 = 30^\circ$

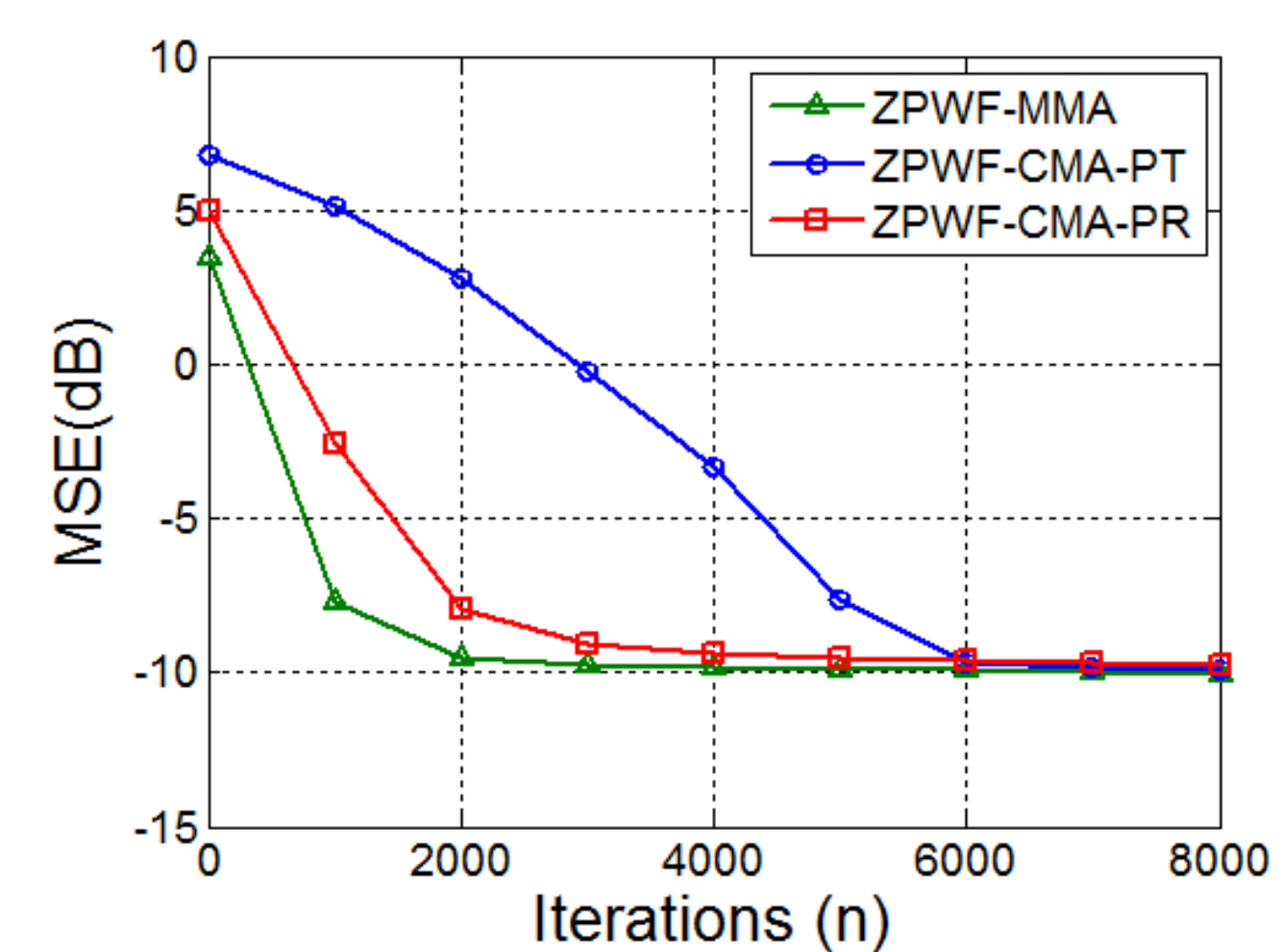


Fig. 6(c).  $\Delta f \cdot T = 10^{-5}$ ,  $\phi_0 = 15^\circ$

Fig. 6. Comparison of the MSE performances among the three different adaptive blind DFEs in different settings with the normalized CFO ( $\Delta f \cdot T$ ) and the phase offset ( $\phi_0$ ).

### Conclusion

In this report, we propose the ZPWF-CMA-PR, the ZPWF-CMA-PT and the ZPWF-MMA which are able to deal with the effect of both the ISI and the CPO caused by the channel. Among the three adaptive blind DFEs, the ZPWF-MMA appears to produce the fastest convergence speed and is the most efficient in terms of MSE when dealing with the CPO.

### Reference

- [1] W.-C. Chang, S.-H. Chuang and J.-T. Yuan, "A Zero-Pole Whitening Filter in Adaptive Blind Decision Feedback Equalizers," in *Proc. IEEE Int. Conf. Syst., Man, Cybern.*, pp. 3259-3264, Oct. 2014.
- [2] J. Labat, O. Macchi, and C. Laot, "Adaptive decision feedback equalization: Can you skip the training period?" *IEEE Trans. Commun.*, vol. 46, no. 7, pp. 921-930, Jul. 1998.
- [3] H. Mathis, "Blind phase synchronization for VSB signals," *IEEE Trans. Broadcast.*, vol. 47, pp. 340-347, Dec. 2001.
- [4] J.-T. Yuan and T.-C. Lin, "Equalization and Carrier Phase Recovery of CMA and MMA in Blind Adaptive Receivers," *IEEE Trans. Signal Process.*, vol. 58, no. 6, June 2010.



2015 輔仁大學電機工程學系  
大學部專題成果展

