OPEN ACCESS

University of BRISTOL

Noune, M. B., & Nix, A. R. (2009). A novel frequency-domain implementation of Tomlinson-Harashima precoding for SC-FDMA. In IEEE 69th Vehicular Technology Conference, 2009 (VTC Spring 2009), Barcelona, Spain. (pp. 1 - 5). Institute of Electrical and Electronics Engineers (IEEE). 10.1109/VETECS.2009.5073320

Link to published version (if available):
10.1109/VETECS.2009.5073320

Link to publication record in Explore Bristol Research
PDF-document

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:
http://www.bristol.ac.uk/pure/about/ebr-terms.html

Take down policy

Explore Bristol Research is a digital archive and the intention is that deposited content should not be removed. However, if you believe that this version of the work breaches copyright law please contact open-access@bristol.ac.uk and include the following information in your message:

• Your contact details
• Bibliographic details for the item, including a URL
• An outline of the nature of the complaint

On receipt of your message the Open Access Team will immediately investigate your claim, make an initial judgement of the validity of the claim and, where appropriate, withdraw the item in question from public view.

A Novel Frequency-Domain Implementation of Tomlinson-Harashima Precoding for SC-FDMA

Mohamed NOUNE and Prof. Andrew NIX

email: Mohamed.Noune@bris.ac.uk, Andy.Nix@bris.ac.uk

Single Carrier Frequency Division Multiple Access (SC-FDMA) is the uplink transmission scheme in the 3GPP LTE standard. SC-FDMA can be used with a range of single carrier equalization techniques to combat ISI. In fact a common assumption in SC-FDMA is to use Linear and Decision Feedback Frequency-Domain Equalization (FDE). We propose the frequency-domain implementation of Tomlinson-Harashima Precoding (THP) for uplink SC-FDMA, as an alternative signal processing technique to equalization, in order to achieve an ISI-free signal at the receiver by performing ISI cancellation prior to transmission.

Why SC-FDMA ?

• OFDMA is not well-suited to the uplink transmission in the 3GPP LTE as a result of its high PAPR.

• SC-FDMA , also known as the DFT precoded OFDMA, has been proposed in the LTE standard for the uplink instead.

• SC-FDMA is also regarded as a form of SC-FDE with a flexibility in resource allocation.
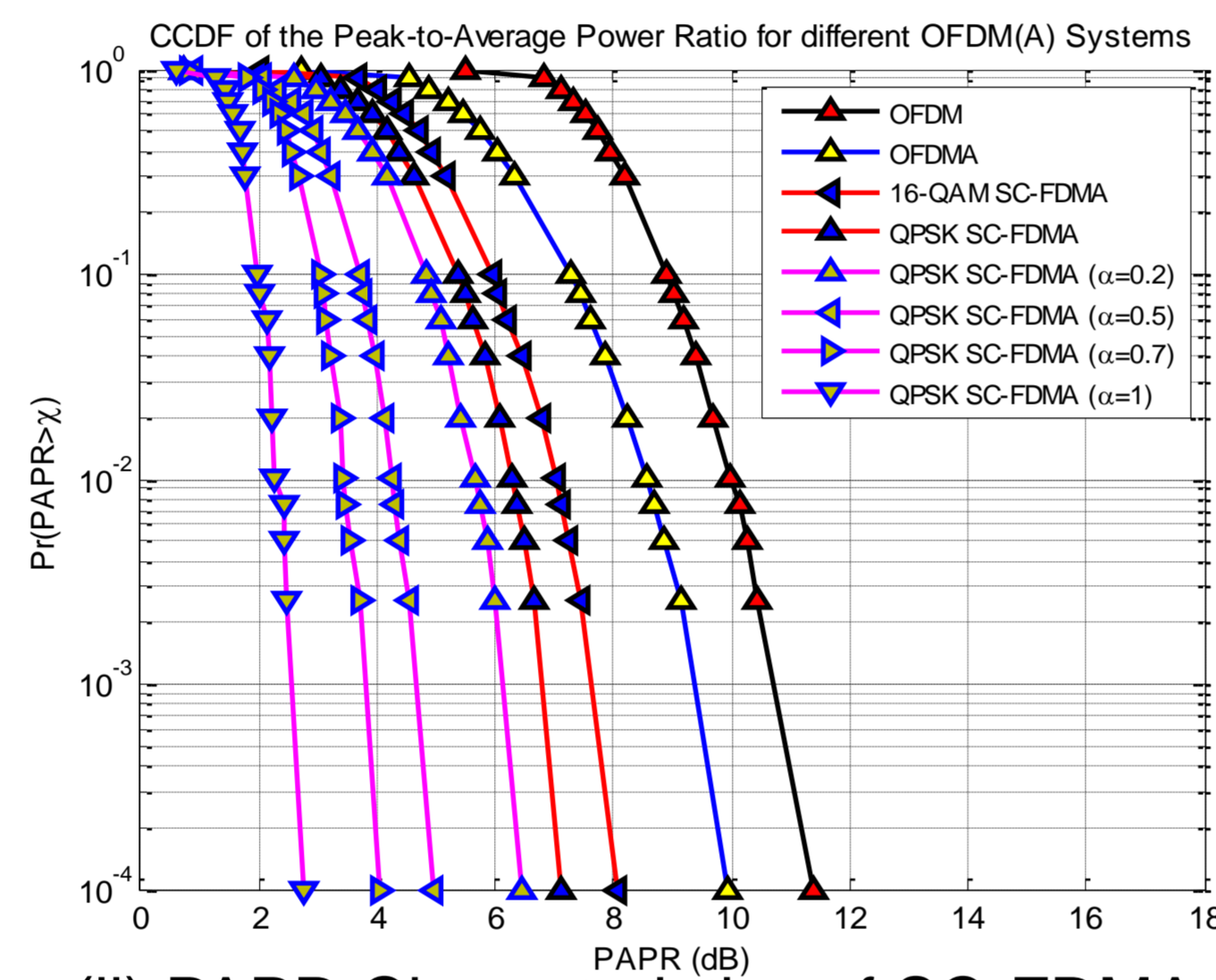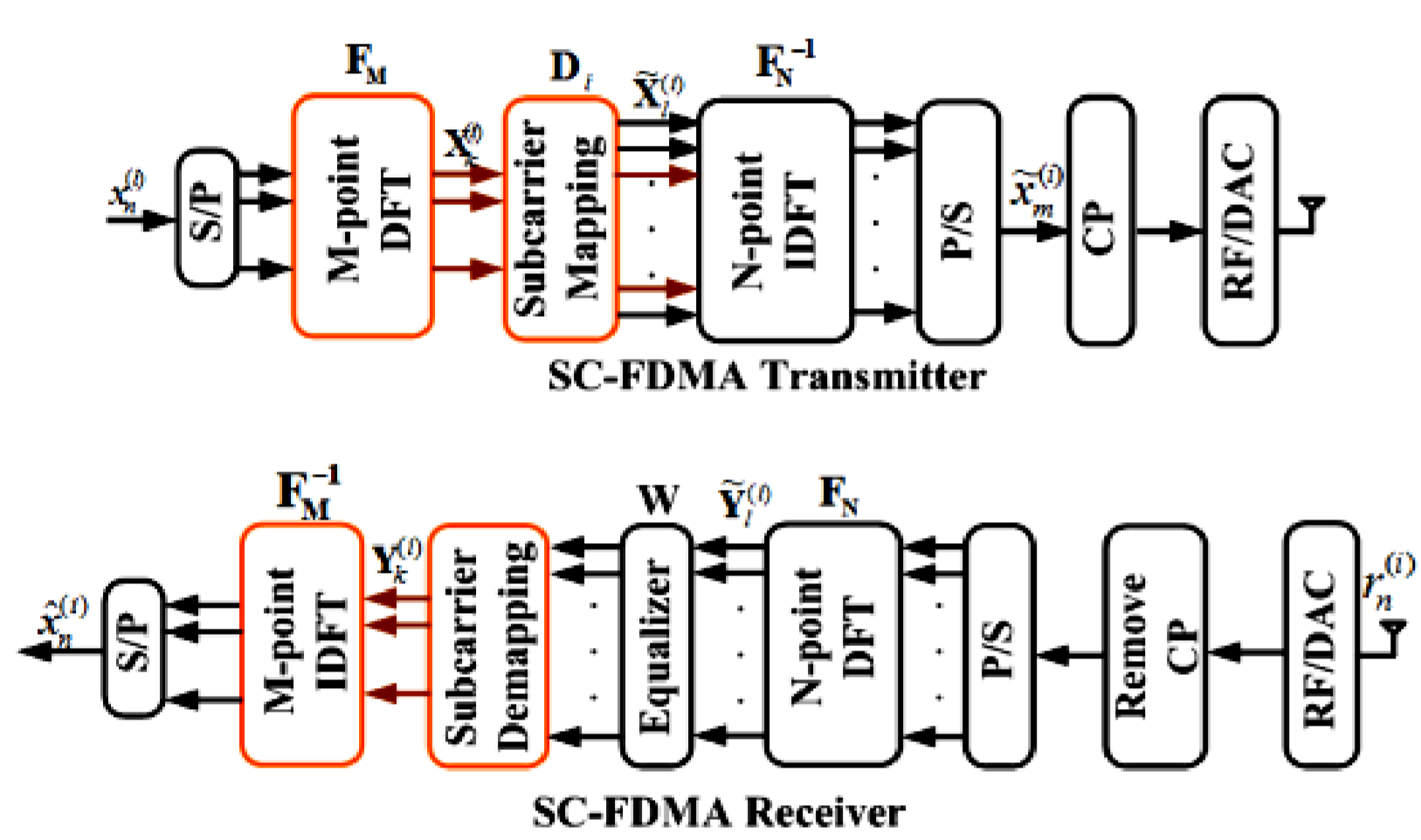
(i) SC-FDMA transmitter and receiver Structures

(ii) PAPR Characteristics of SC-FDMA

SC-FDMA Transceiver and PAPR

Performance of SC-FDMA with FDE :

• FDE is a very attractive signal processing technique to deal with large time dispersive multipath channels, and can be implemented in the form of an FD-LE or an FD-DFE.

• Although FD-DFE offers a performance that is superior to FD-LE, it suffers from a performance degradation as a result of error propagation, especially for long delay spread channels and coded systems.
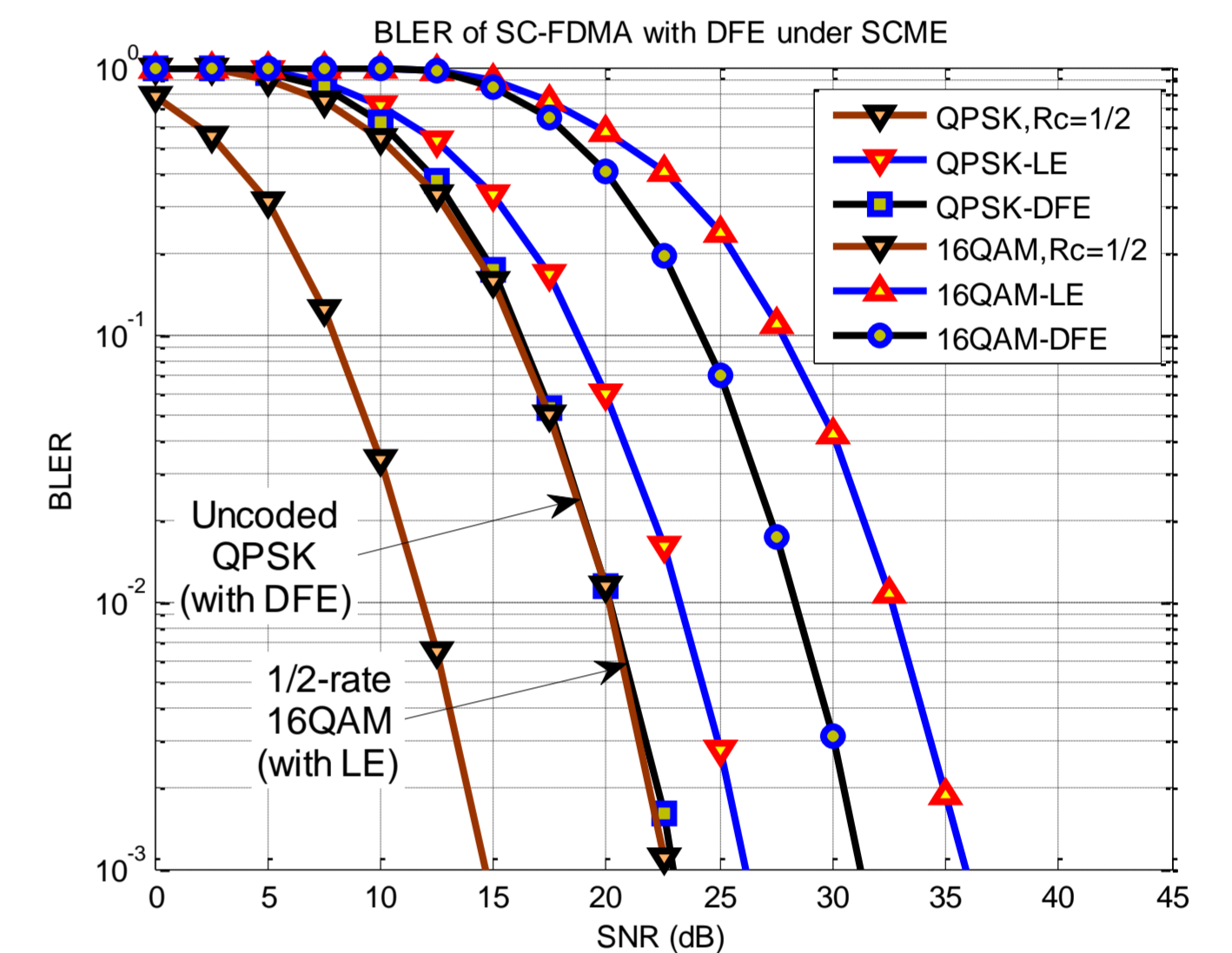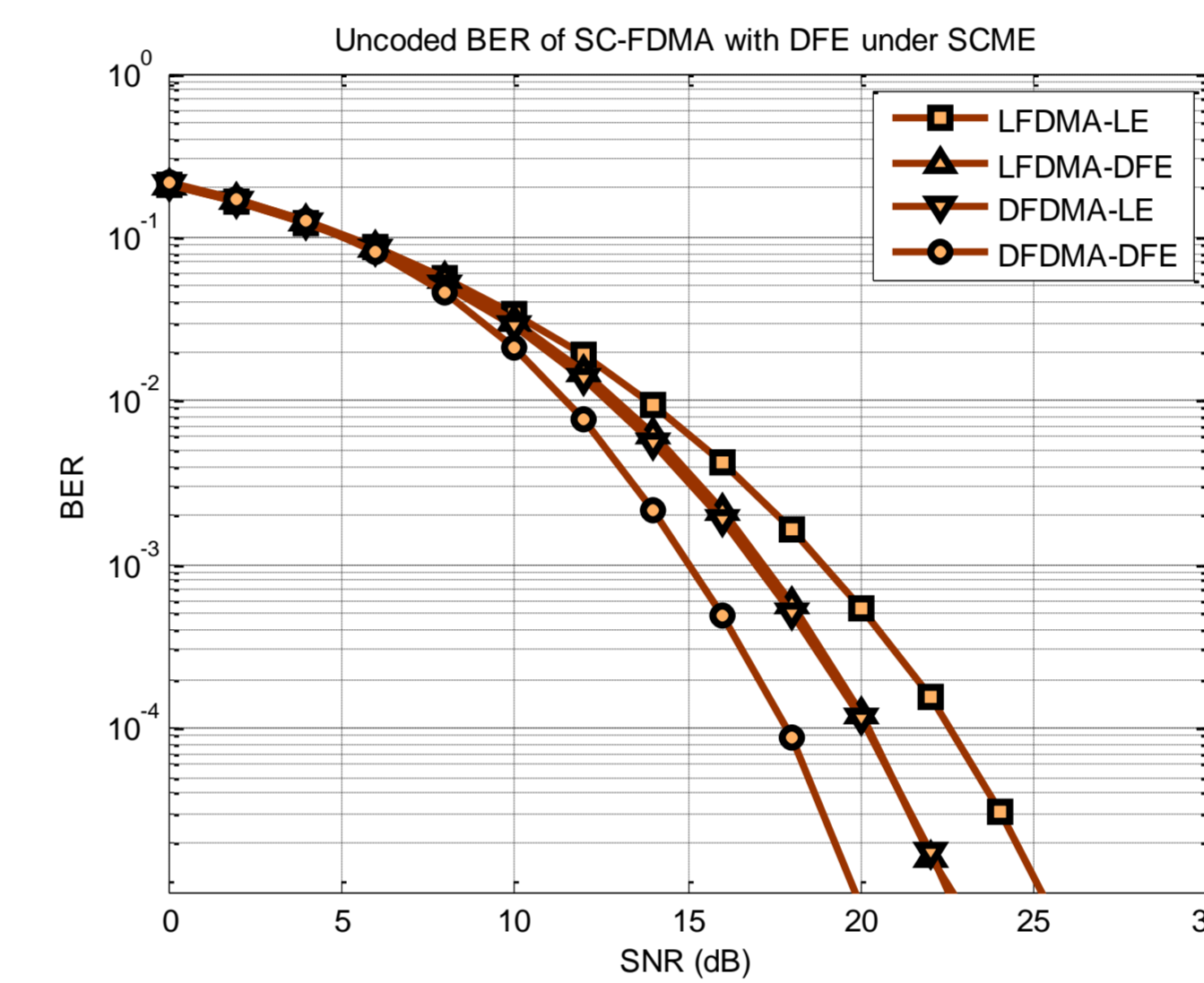
(i) Uncoded BER of SC-FDMA with FDE

(ii) BLER of SC-FDMA with FDE

Performance of SC-FDMA with FDE under SCME

Tomlinson-Harashima Precoding :

• THP tackles the error propagation problem in a DFE and offers a further improvement when coding is applied.

• THP combats ISI transmissions, and achieves transmission at the full channel capacity.
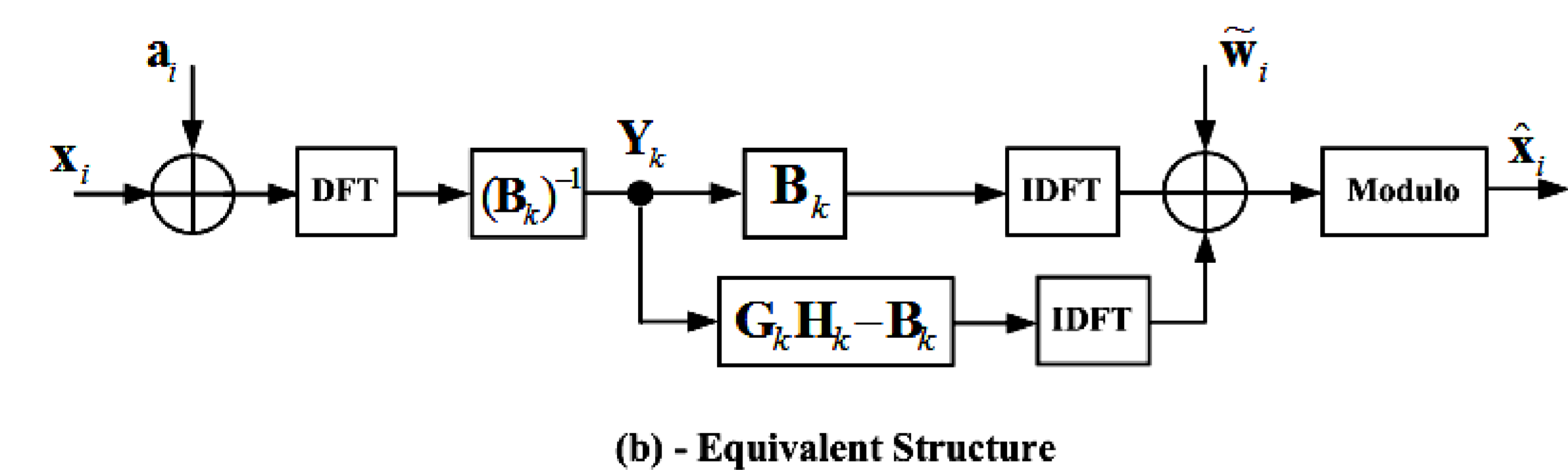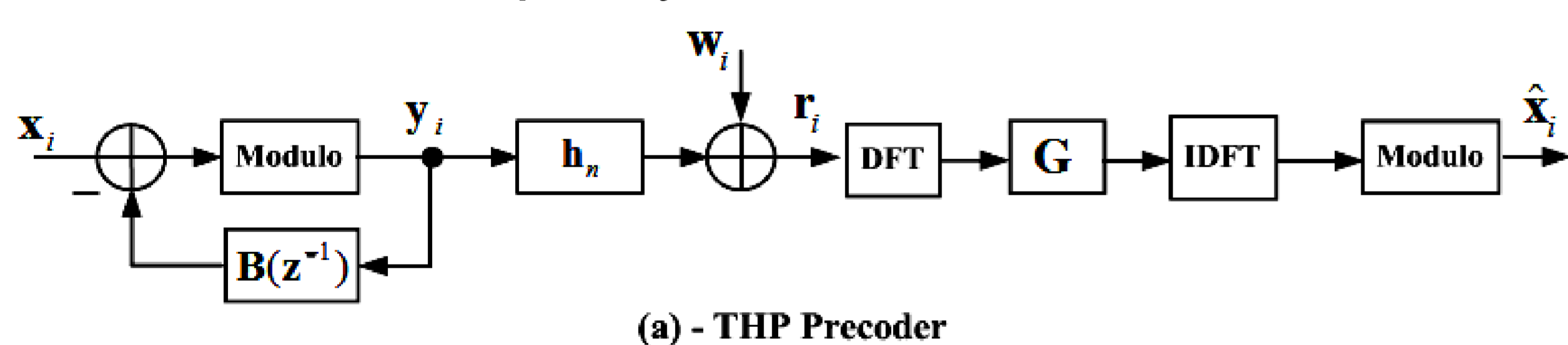
(a) - THP Precoder

(b) - Equivalent Structure

Structure of conventional Tomlinson-Harashima Precoding

• The output of the THP is:
$$y_n = x_n - \sum_{m=1}^{L} b_m y_{n-m}$$
L is the channel delay spread.

TD Tomlinson-Harashima Precoding for SC-FDMA :

• The time-domain operation of THP is connected to the signal constellation, SC-FDMA, however, does not have a distinct constellation.

• The precoder's input is the SC-FDMA signal after CP insertion transforms the linear convolution into cyclical convolution.

• By rearranging the previous equation and taking the N-point DFT:
$$X_k = \left(1 + \sum_{n=1}^{L} b_n e^{-j2\pi \frac{kn}{N}}\right) Y_k = B_k Y_k$$

• The Tdomain implementation of THP is a realizable and effective implementation, especially as the channel delay spread increases.

• The THP coefficients can be designed according to the ZF or MMSE criterion.

(i) PAPR of ZF and MMSE THP.

(ii) BER of ZF and MMSE THP

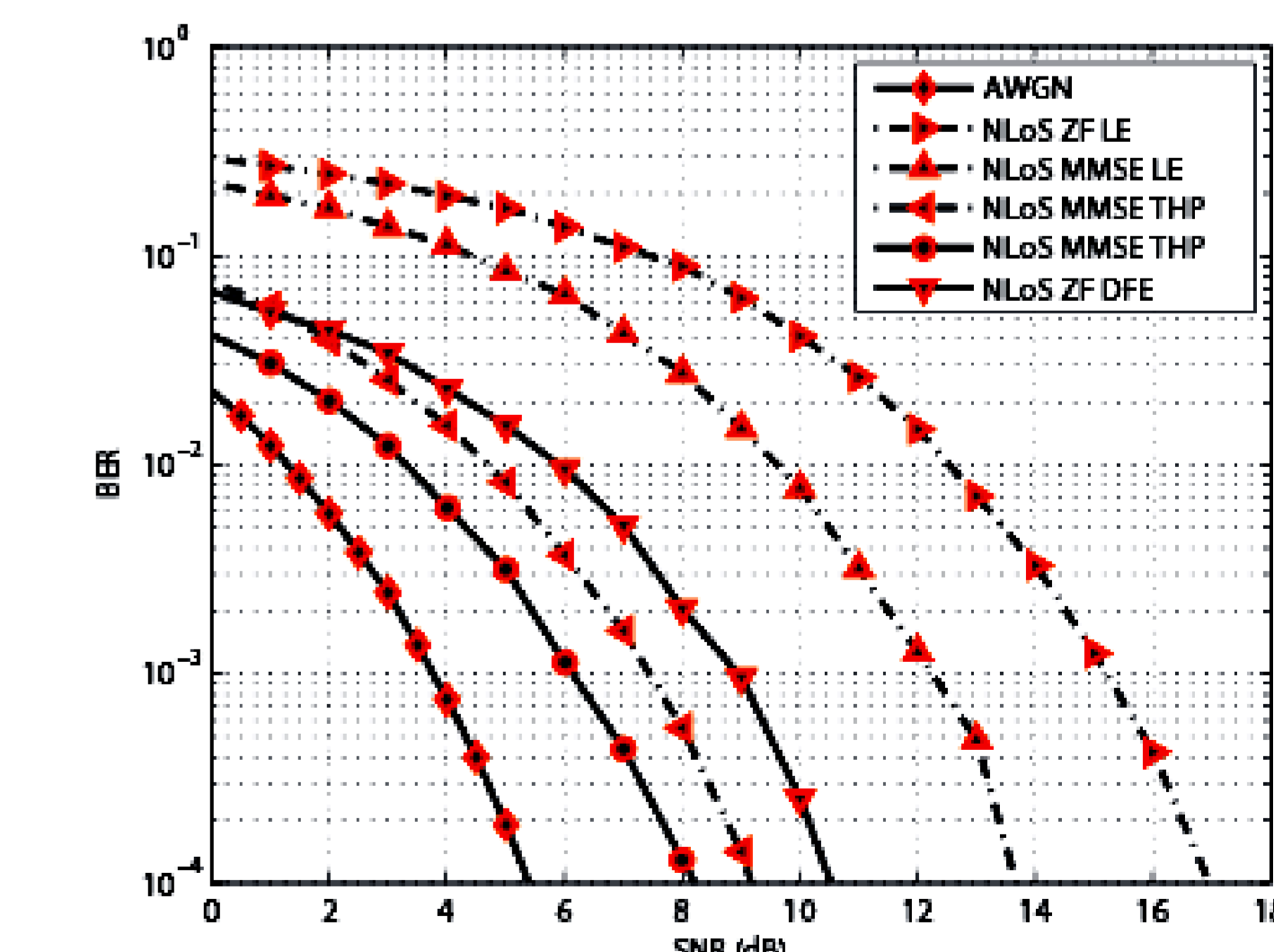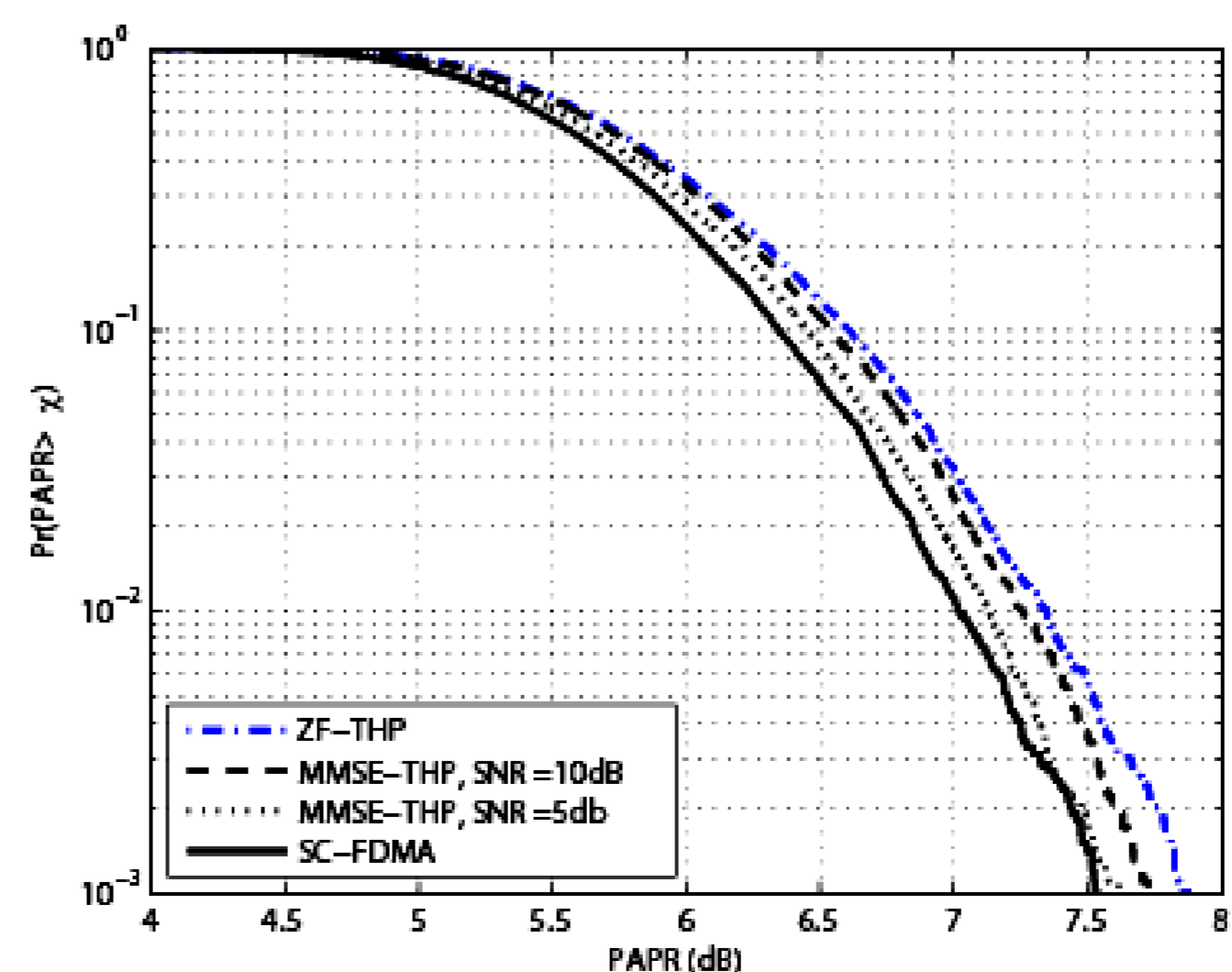Performance of SC-FDMA with THP under SCME

Conclusions :

• THP achieves the ideal-DFE performance for coded and uncoded systems.

• Precoding requires perfect knowledge of the uplink channel at the transmitter.

• Because the PAPR of the precoder's output is dependent on the channel fading, it is essential to employ some form of PAPR reduction.

University of BRISTOL

CCr
communications
research