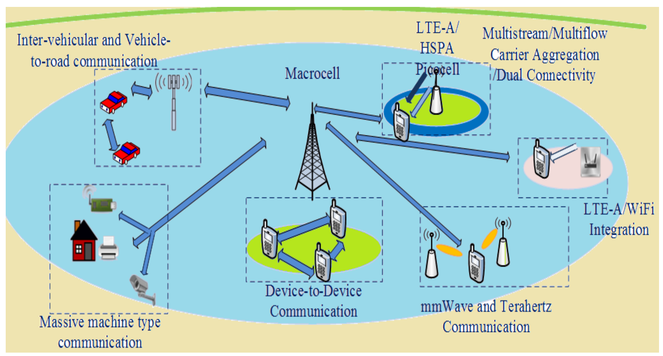
Subcarrier index modulation based flexible OFDM system

Chengbo Liu, Yafei Hou, Takeshi Higashino and Minoru Okada
Network Systems Laboratory, Graduate School of Information Science
Nara Institute of Science and Technology (NAIST)

Introduction

OFDM system is widely utilized for many applications such as HDTV and 4/5G wireless systems.

4/5G

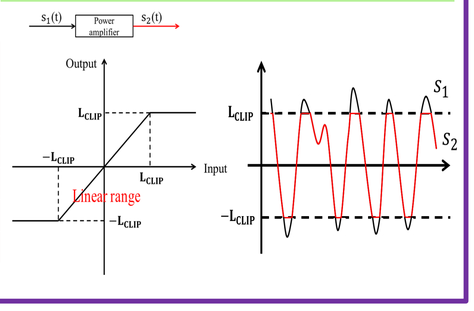


OFDM systems have such issues:

1) High-order M-QAM modulation maybe cannot be guaranteed due to low received signal power.

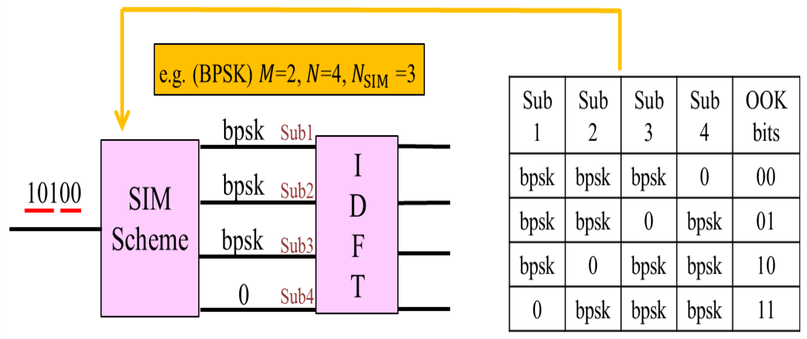
2) OFDM requires expensive power amplifier with high requirement of linearity, which results in the terminal high cost and battery drain due to high PAPR.

Modulation	Bits per symbol	Constellation points	Eb/No required for BER = 10^{-5}
BPSK	1	2	9.5 dB
QPSK	2	4	9.5 dB
16-QAM	4	16	13.4 dB
64-QAM	6	64	17.8 dB



Subcarrier Index Modulation (SIM) with OFDM (SIM-OFDM)

SIM-OFDM utilizes N_{SIM} active subcarriers to transmit symbols modulated by M-QAM and the other subcarriers which are set to zero are inactive.

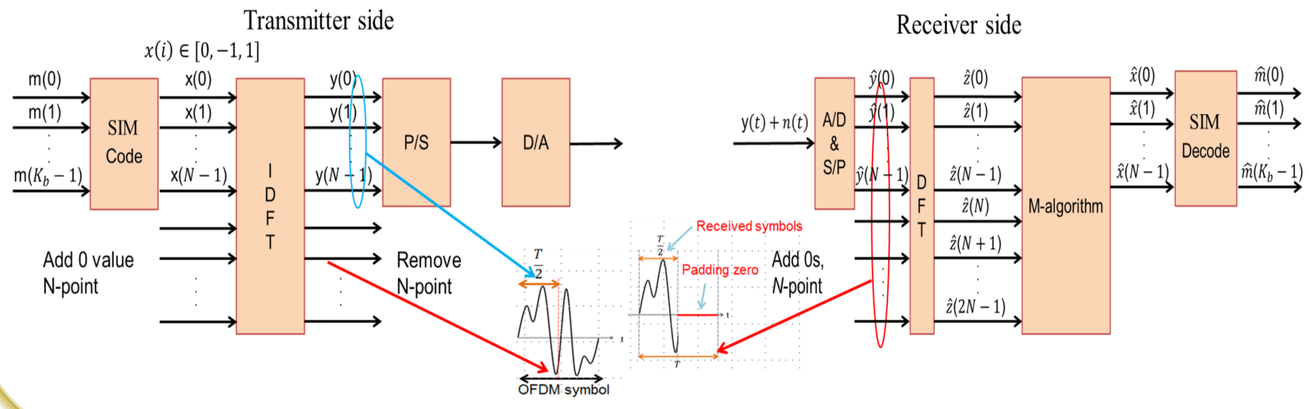


Sub 1	Sub 2	Sub 3	Sub 4	OOK bits
bpsk	bpsk	bpsk	0	00
bpsk	bpsk	0	bpsk	01
bpsk	0	bpsk	bpsk	10
0	bpsk	bpsk	bpsk	11

Proposed systems

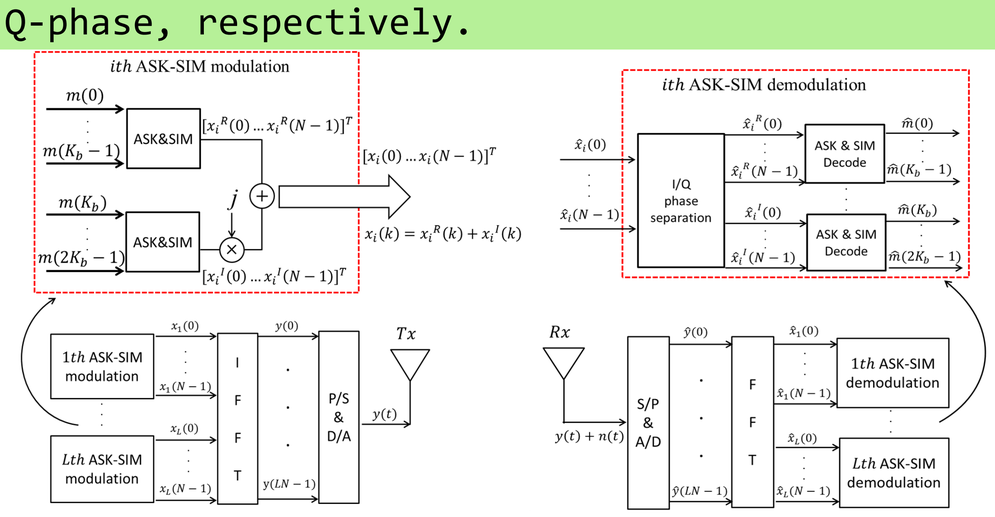
Proposal 1: HS/BPSK/SIM-OFDM

Proposal 1 transmits half time-domain symbols and utilizes M-algorithm which sets U initial estimated points and selects the candidate constellation points (M) at each iteration to demodulate received symbols.



Proposal 2: Double ASK-SIM for OFDM system

Proposal 2 utilizes ASK-SIM on the I-phase and Q-phase, respectively.

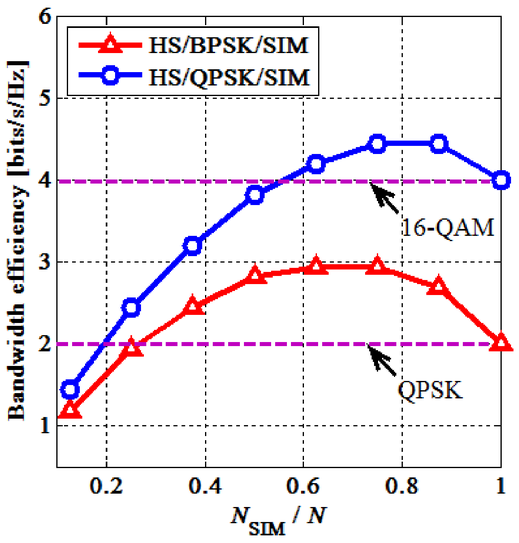


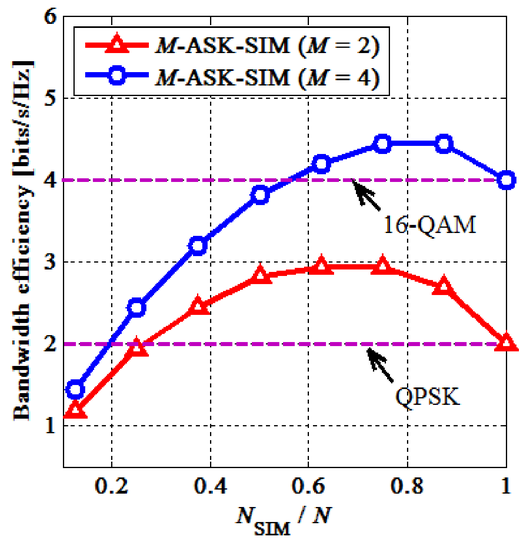
Parameters and Bandwidth efficiency

Parameters	Proposal 1	Proposal 2
Channel model	EPA	EPA
FFT size	128	128
Modulation	BPSK	2-ASK
Equalization	MMSE	MMSE
$M-\text{algorithm}(U,M)$	(4, 16)	N/A
Number of carriers(N)	32	32
Bandwidth	20 MHz	20 MHz

EPA power delay profile		
Tap number	Power (dB)	Delay (ns)
1	0	0
2	-1	30
3	-2	70
4	-3	90
5	-8	110
6	-17.2	190
7	-20.8	410

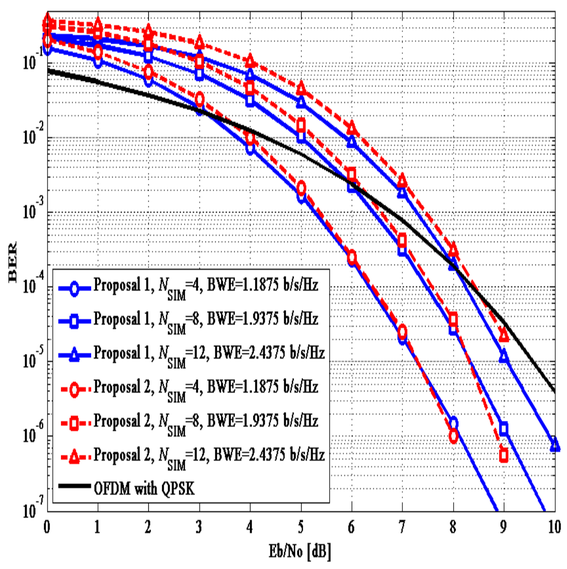
Bandwidth efficiency



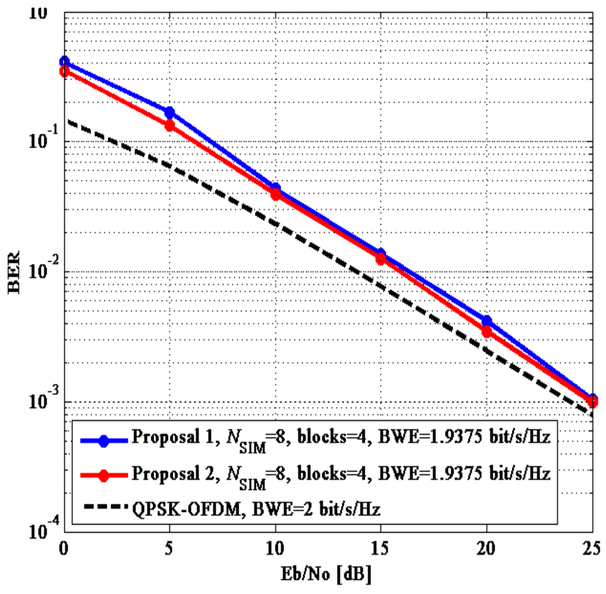


Simulation results and conclusion

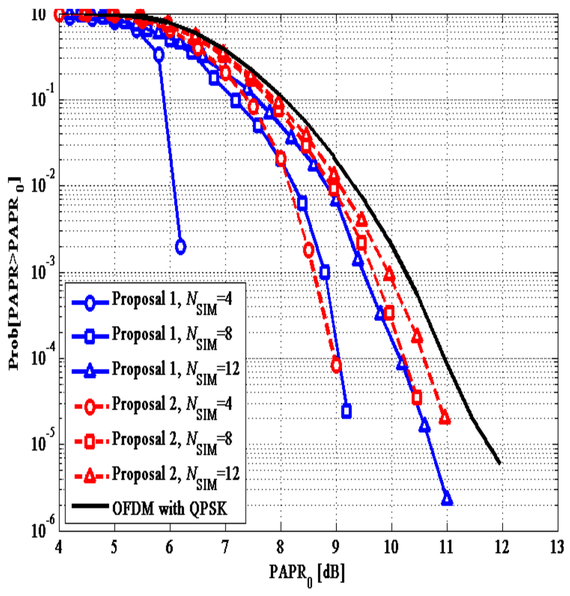
AWGN Channel



Fading Channel



PAPR performance



Conclusion

Compared with conventional OFDM system, HS/BPSK/SIM-OFDM and double ASK-SIM for OFDM :

- Achieve almost the same BWE with low-order M-QAM and better PAPR performance.
- Are more sensitive to fading channel.
- Provide the design freedom degree with a flexible range of BWE for system design.