

Project	IEEE 802.16 Broadband Wireless Access Working Group < http://ieee802.org/16 >	
Title	OFDM vs. SC-FDE Literature Survey	
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Re:	802.16m SDD call for contributions, uplink MA scheme.	
Abstract	Academic research papers provide an objective opinion about the topic. The results surveyed from multiple sources shed light on the comparison at hand. This gives a unique opportunity to see where the multiple results are converging. SC is shown to have some edge in the surveyed papers. This calls for a more thorough study before making a final conclusion.	
Purpose	To discuss the performance for different UL MA schemes.	
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OFDM vs. SC-FDE

Literature Survey

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Why Literature Surveying?

- Academic research papers provide an objective opinion about the topic
- The results surveyed from multiple sources shed light on the comparison at hand
- This gives a unique opportunity to see where the multiple results are converging.

OFDM vs. SC-FDE

- Many research papers tackled the performance/complexity comparison between single carrier and OFDM communication system
 - Here a brief snap shot of some of those papers is presented
 - The information contained in the papers are publicly available and verifiable
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References Cited

- [1] Jan Tubbax et al “OFDM versus Single Carrier: A Realistic Multi-Antenna Comparison” EURASIP Journal on Applied Signal Processing 2004:9, pp 1275–1287.
 - [2] Nevio Benvenuto and Stefano Tomasin, “On the Comparison Between OFDM and SingleCarrier Modulation With a DFE Using a Frequency-Domain Feedforward Filter,” IEEE TRANSACTIONS ON COMMUNICATIONS, VOL. 50, NO. 6, JUNE 2002.
 - [3] David Falconer et al, “Frequency Domain Equalization for Single-Carrier Broadband Wireless Systems,” IEEE Communications Magazine, April 2002, pp 58-66.
 - [4] Jianfei Li et al, “Comparison of Spectral Efficiency for OFDM and SC-FDE under IEEE 802.16 Scenario ,” ISCC 06. Proceedings. 11th IEEE Symposium on Computers and Communications, 2006, June 2006, pp 467 – 471.
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SC Vs OFDM

**First: the case of no-coding
or weak coding**

From [1]

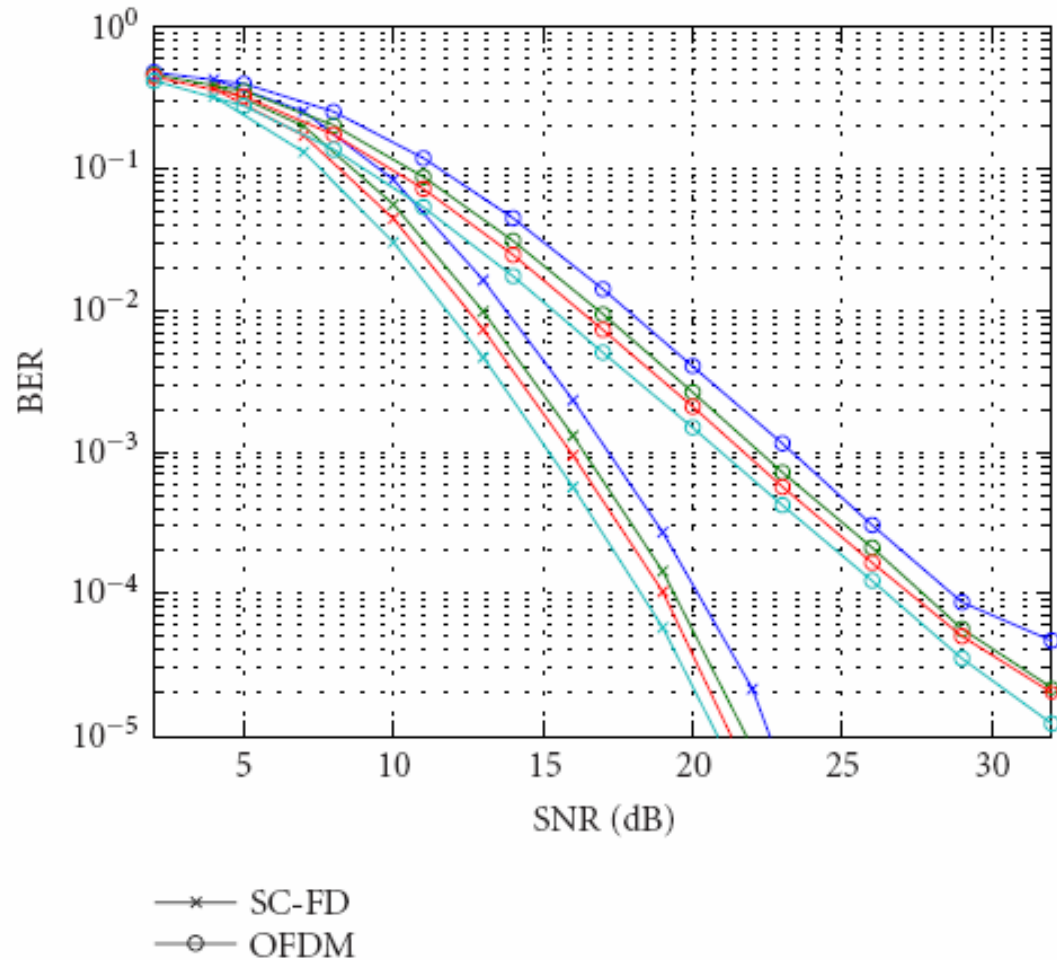


FIGURE 9: The impact of PA back-off $P_{1\text{ dB}} = [\infty 6.4 4.4 2.4]$ dBm on SC-FD and OFDM in multipath with coding ($R = 3/4$), channel/noise estimation, clipping (4σ) and quantizing, (8 bits) and SRRC filtering ($\alpha = 0.25$).

From [1]

- Counting all the effects such as filtering, quantization, Power Amplifier non-linear effects, etc.
 - The channel was a simple fading channel.
 - Coding was rate $\frac{3}{4}$
 - Overall, SC outperforms the OFDM by more than 10dB at 10^{-5} BER
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From [2]

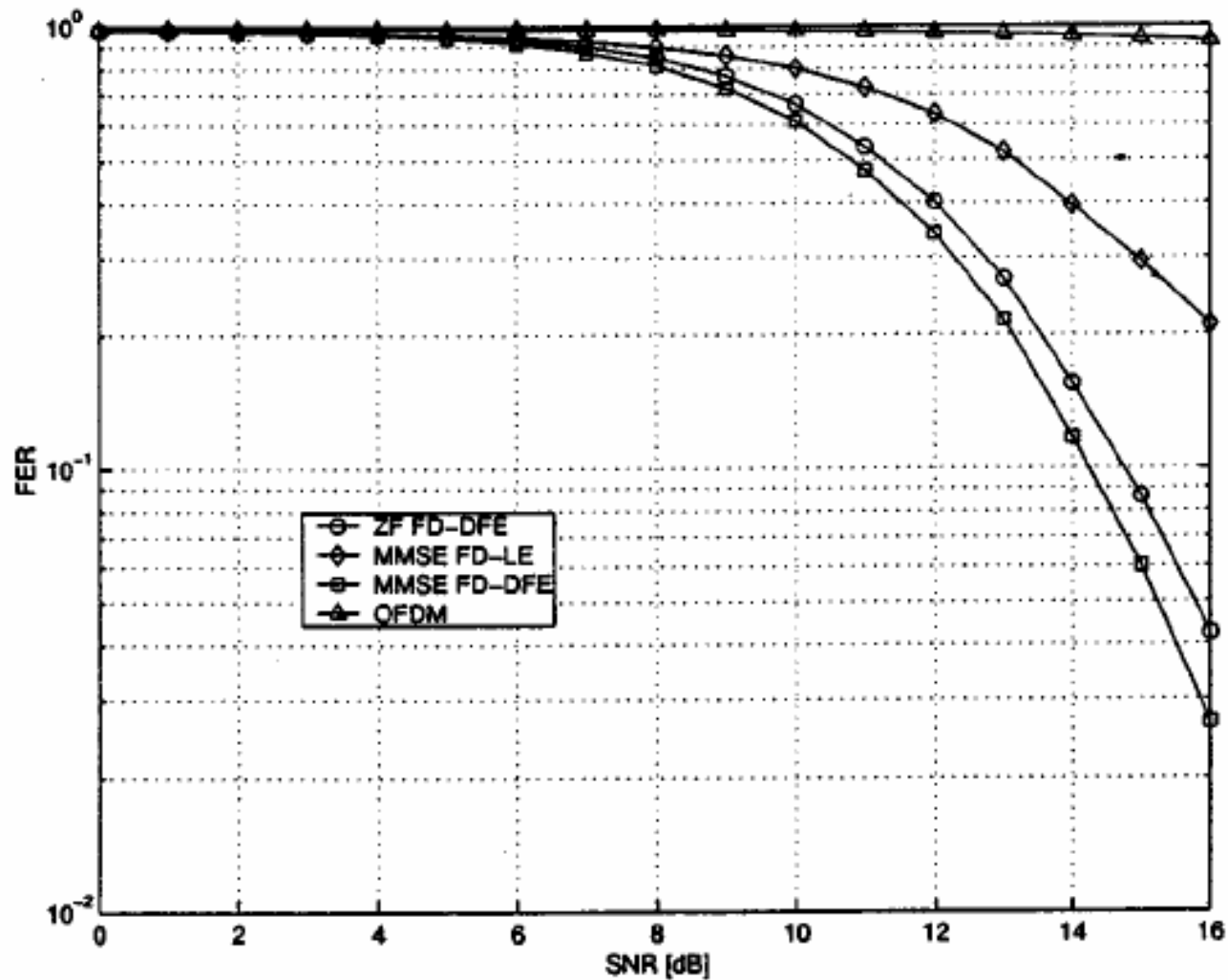
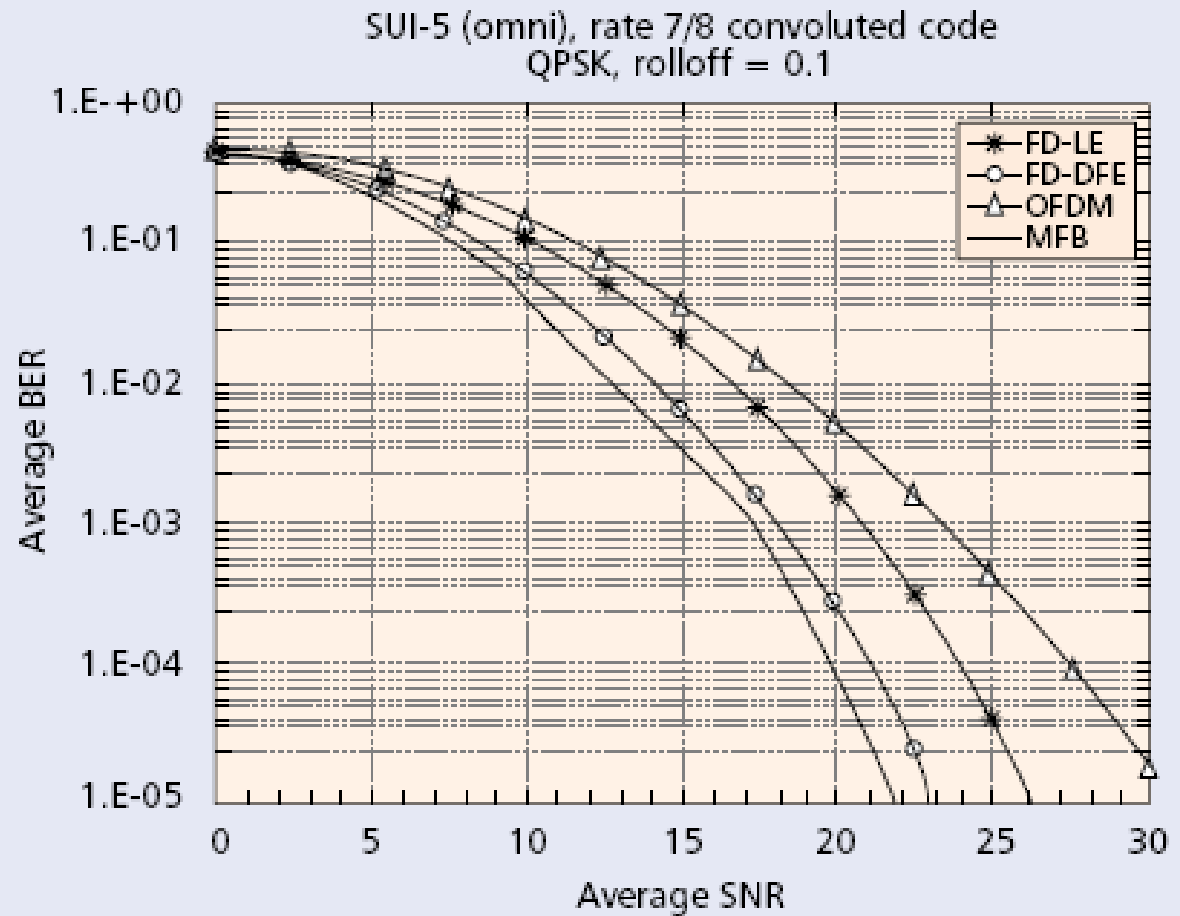


Fig. 7. Mean frame error rate, in the absence of coding, for different equalizer structures as a function of the SNR .

From [2]

- No line of sight multipath channel. The channel has a Rayleigh characteristic with an exponential decaying power profile with an *rms* delay spread of 100 ns.
 - SC clearly outperforms the OFDM
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From [3]



performance comparison for systems with perfect channel knowledge on SUI-5 channel model for QPSK with code rate 7/8.

From [3]

- The SC in this environment outperforms the OFDM as well



SC Vs OFDM

Second: the case of strong coding

From [1]

In [1] it is stated that if stronger code is used the difference between SC and OFDM will shrink but SC will remain ahead

“While the absolute numbers of the respective degradations change, the general conclusions ... remain valid”.

From [2]

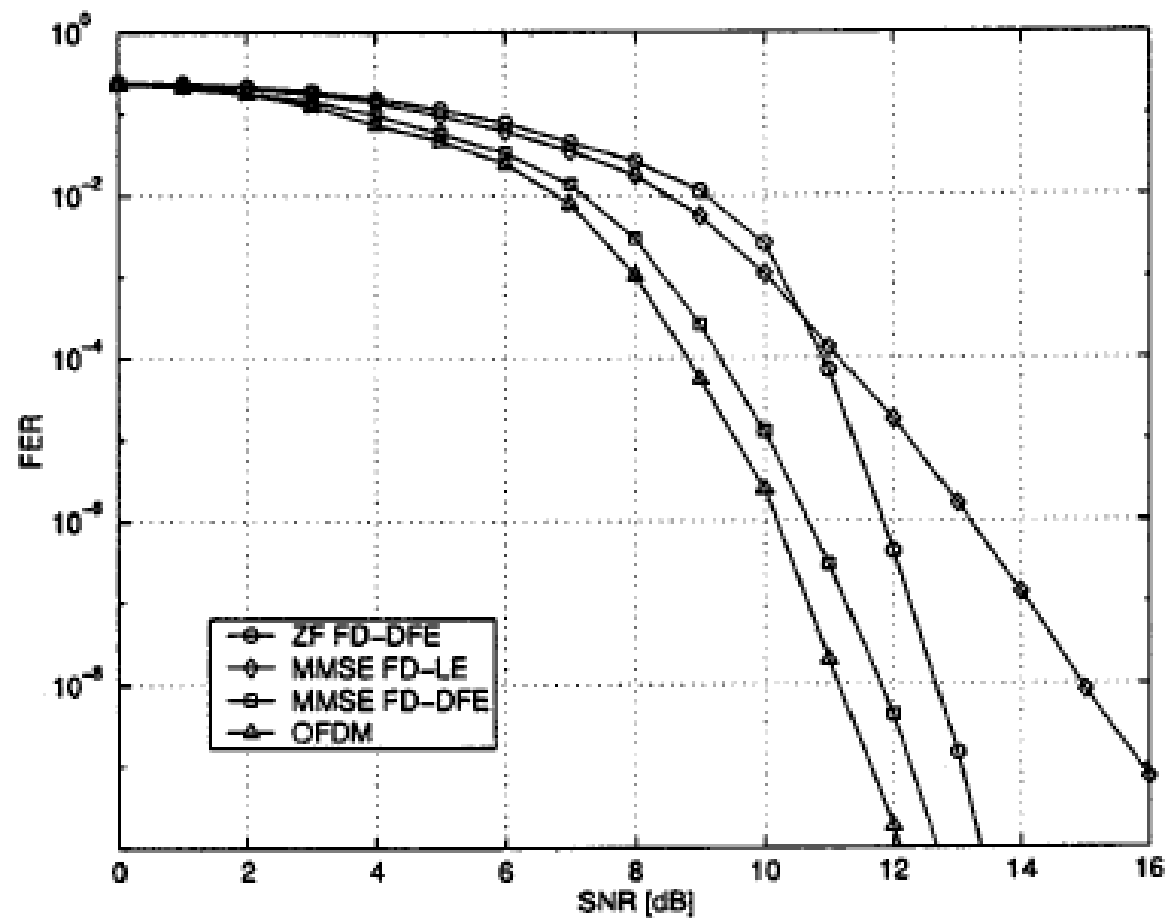
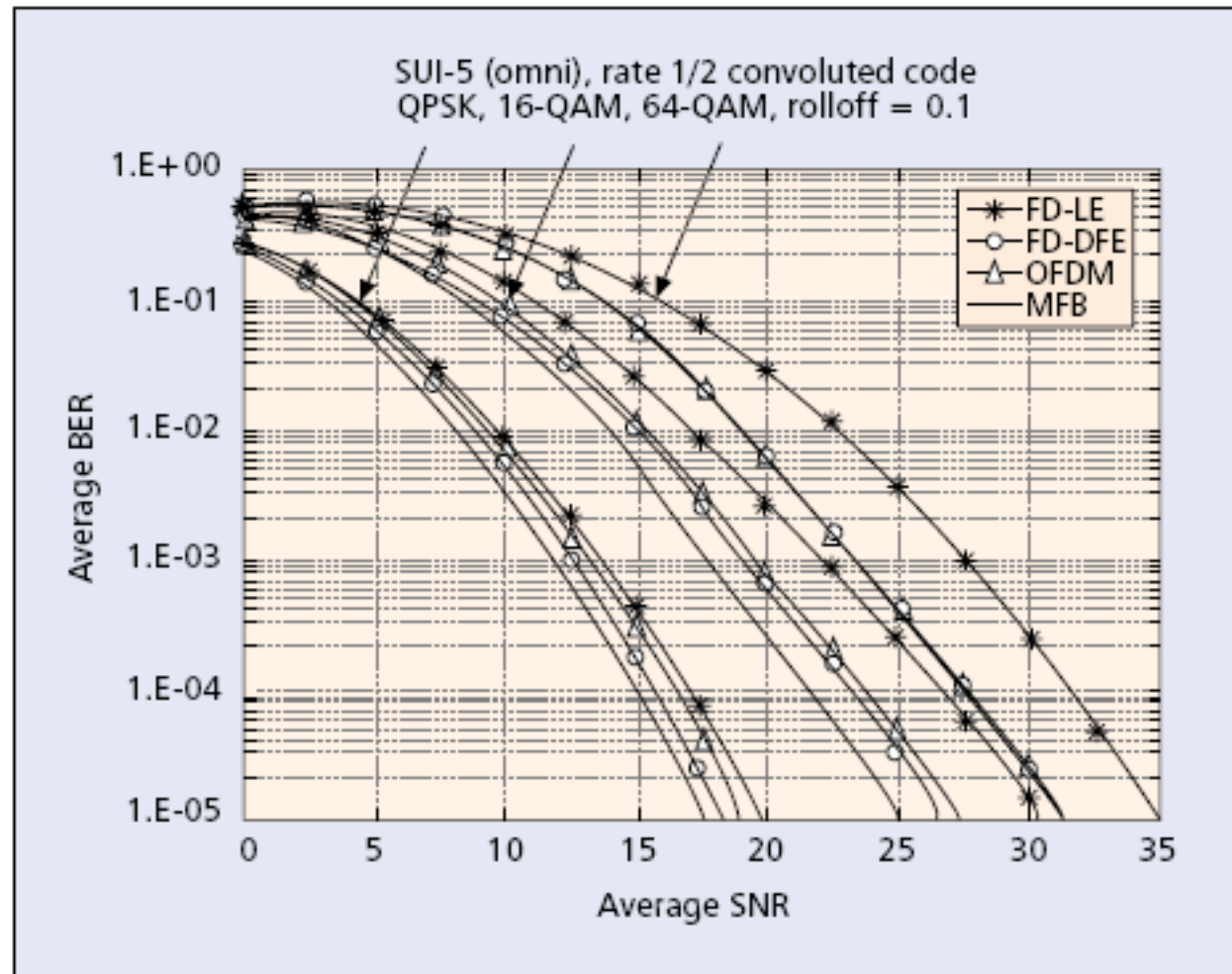


Fig. 6. Mean frame error rate, in the presence of coding, for different equalizer structures as a function of the SNR .

From [3]



■ Figure 10. Performance comparison for systems with perfect channel knowledge on SUI-5 channel for code rate 1/2.

From [4]

- SUI-5 channel
- Coded OFDM
- SC uses adaptive modulation scheme

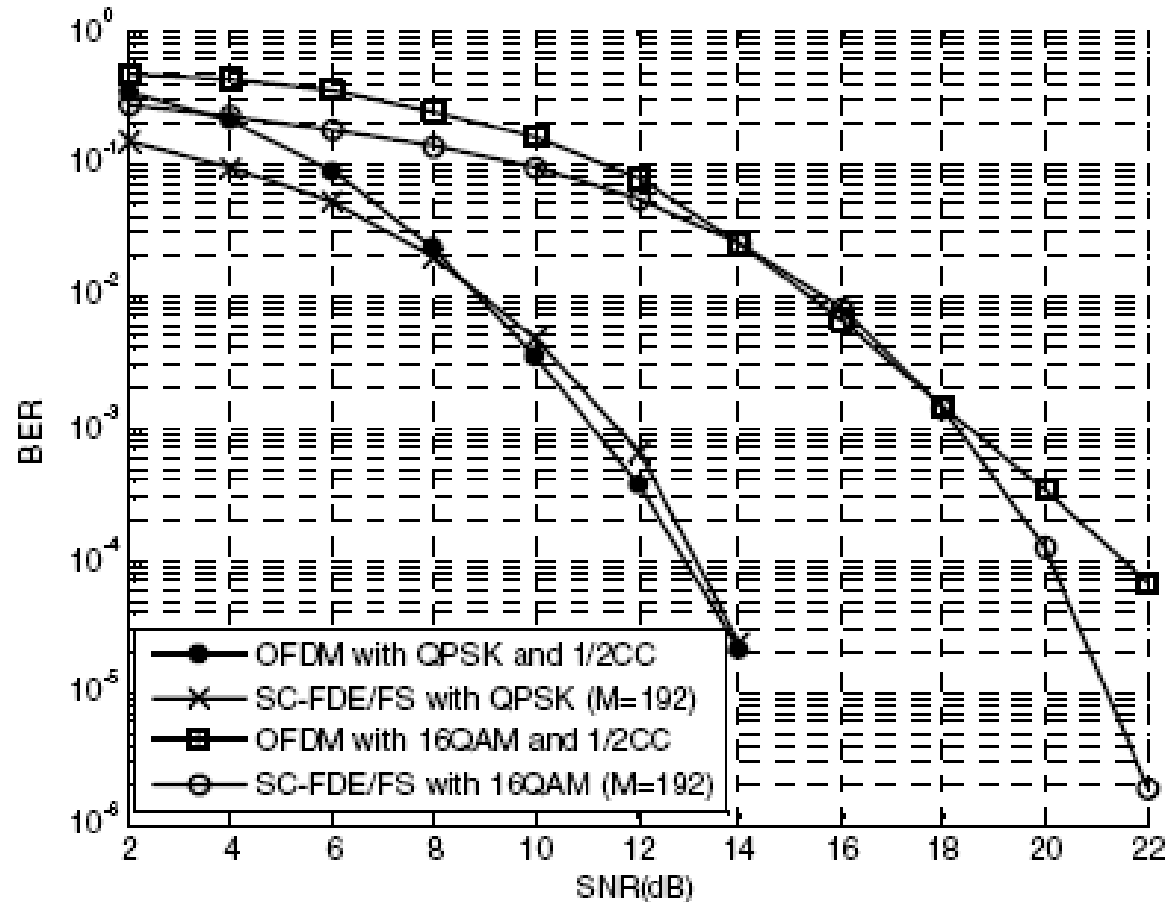


Figure 5. Comparison between coded OFDM and SC-FDE/FS under Channel B.

Strong Coding

- The difference between OFDM and SC shrinks as coding compensates for the error generated in OFDM symbols due to corrupted tones.
 - From [1] and [3], the SC still outperforms the OFDM. From [2] OFDM has $\frac{1}{2}$ dB edge. From [4]: it depends on setting, but difference is small.
 - Only reference [1] covers the effect of power amplifier on the performance and the SC has a large advantage over OFDM
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SC Vs OFDM

Third: the DFE

From [2]

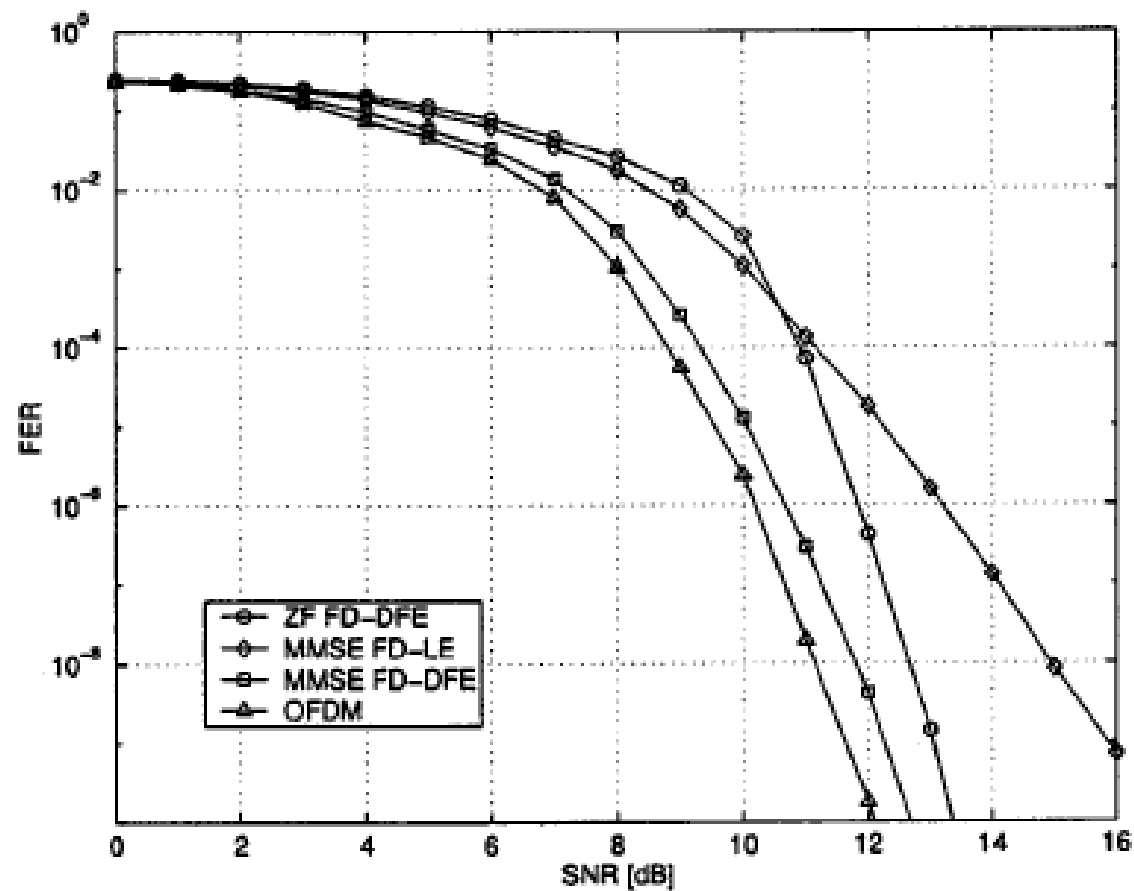
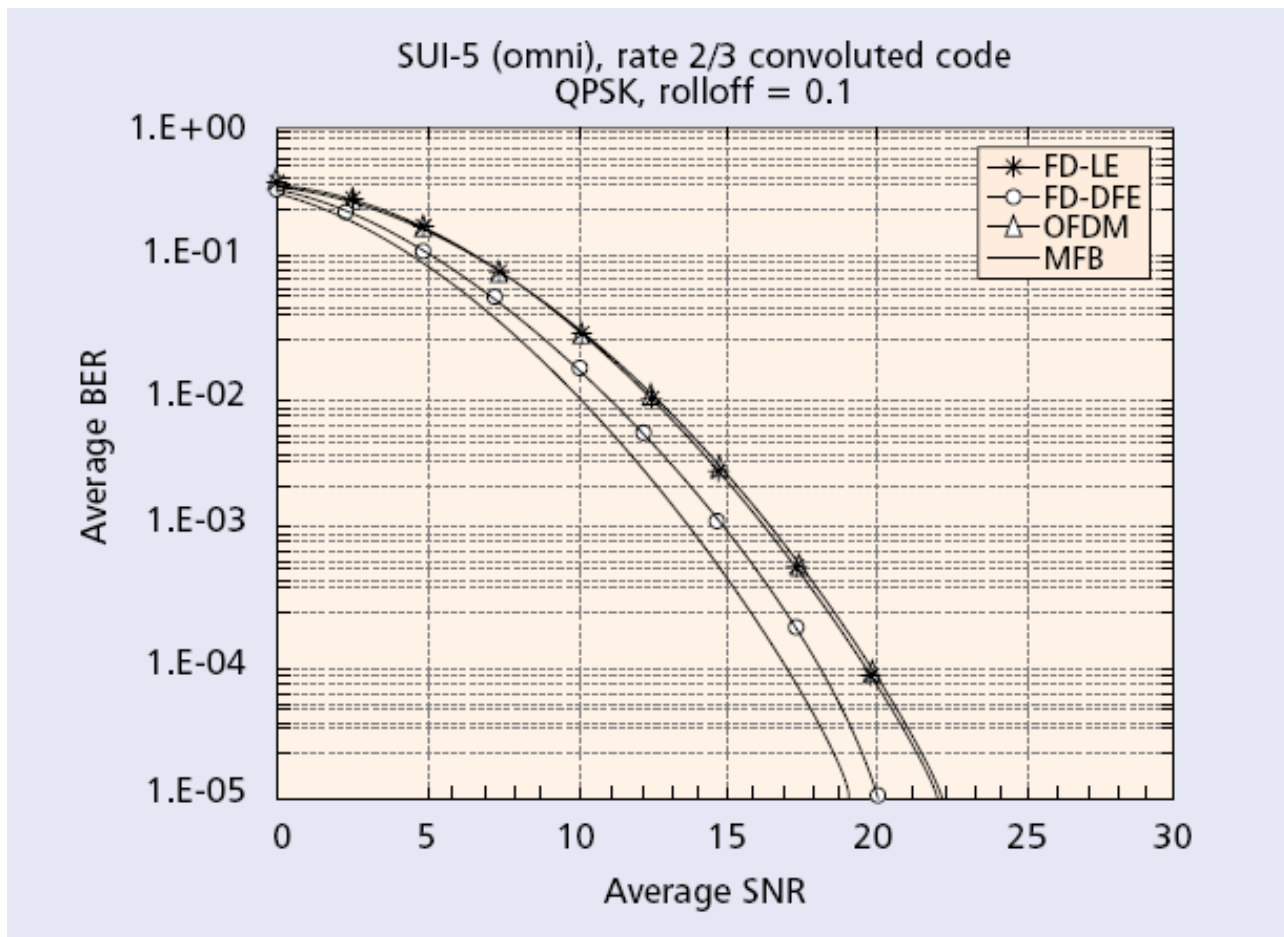


Fig. 6. Mean frame error rate, in the presence of coding, for different equalizer structures as a function of the SNR .

From [3]



Performance comparison for systems with perfect channel knowledge on SUI-5 channel model for QPSK with code rate 2/3

DFE

- Using DFE with the SC-FDE gives a clear advantage over using the MMSE receiver.
 - This appears to be true in all the cases covered in the references.
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Survey Conclusions

- The papers covered show an edge for the SC over the OFDM
 - The group should give a serious consideration to the ULMA using SC.
 - It is possible that OFDM has some gain in the particular environment we are tackling
 - This calls for a more thorough study before making a final conclusion
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