Battle of the Waveforms for 5G

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OFDM/OFDMA

Orthogonal Frequency Division Multiplexing/Orthogonal Frequency Division Multiple Access: *Enables transmission of parallel data streams*

- ☑ High data rates
- ☑ Robustness to frequency selectivity
- ☒ Sensitivity to time/frequency offsets
- ☒ High peak to average power ratio (PAPR)
- ☒ High sidelobe levels

5G Challenges

Solutions to OFDM/OFDMA problems:

- ↓ Spectral efficiency
- ↓ Energy efficiency

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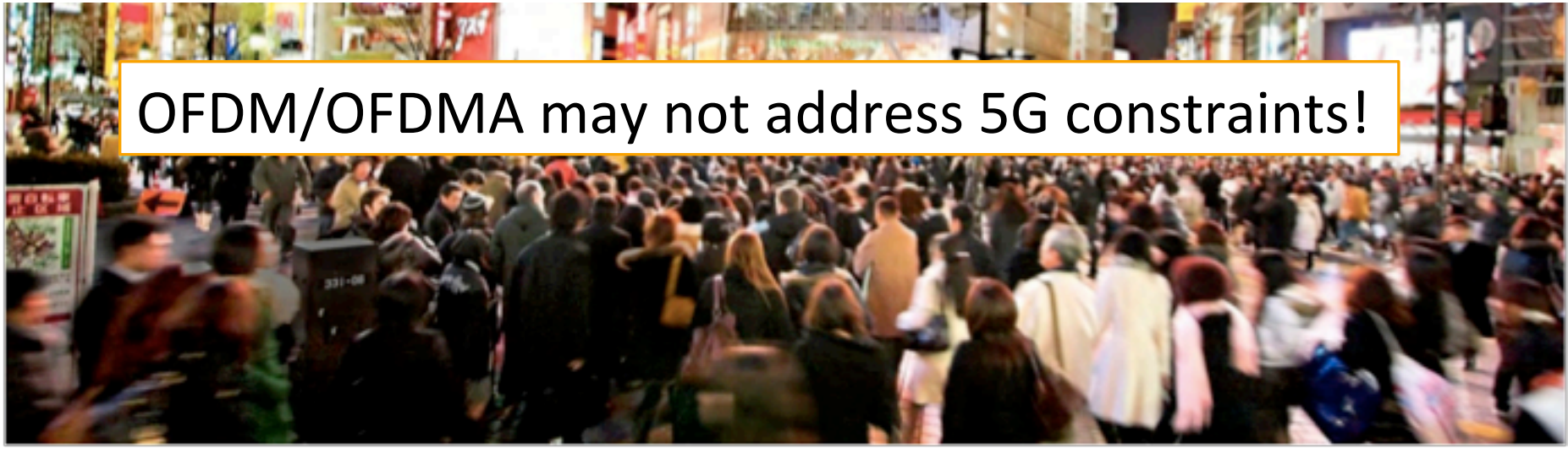

5G Challenges

Solutions to OFDM/OFDMA problems:

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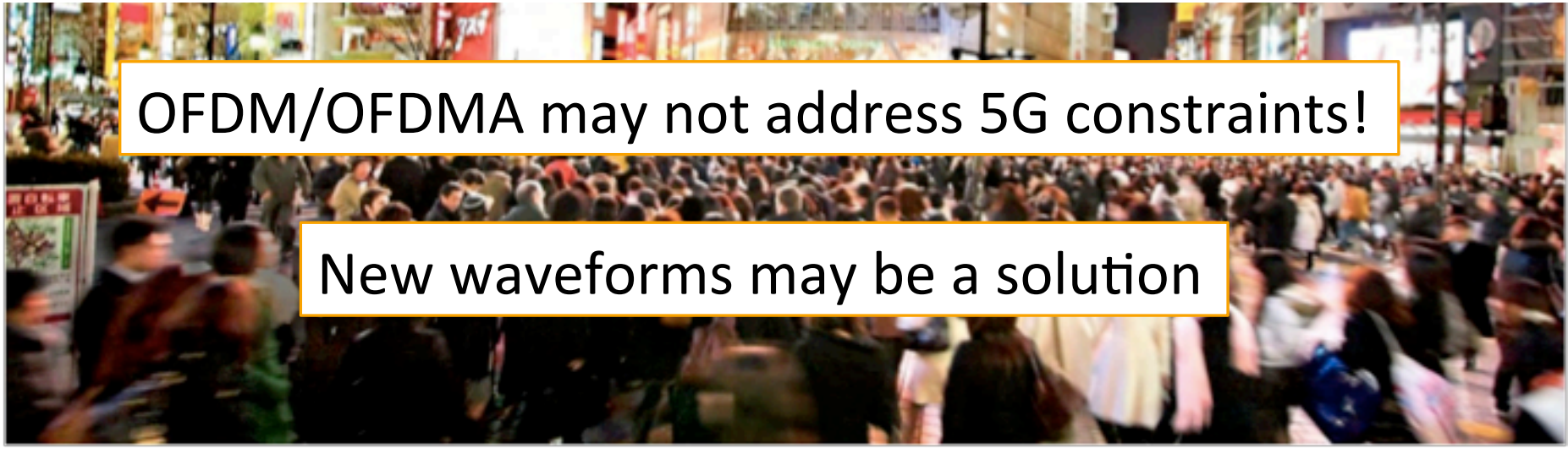
- ↓ Energy efficiency



Design Targets

↑ Spectral efficiency

↑ Energy efficiency

↓ PAPR

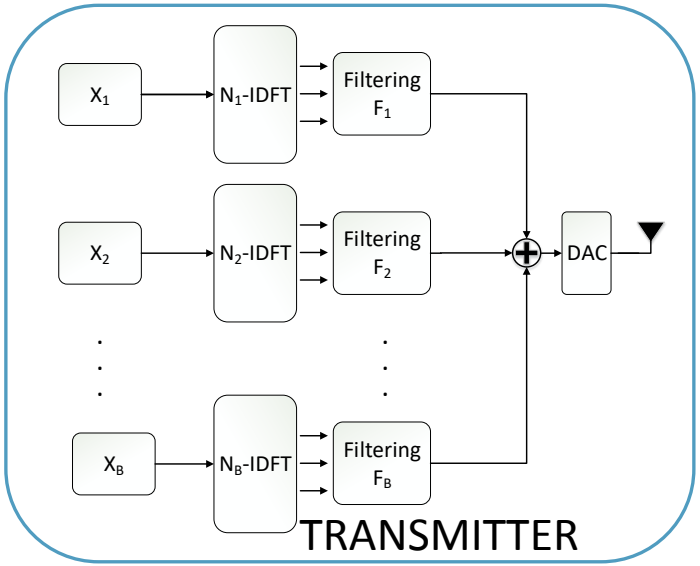
↓ Sidelobe levels

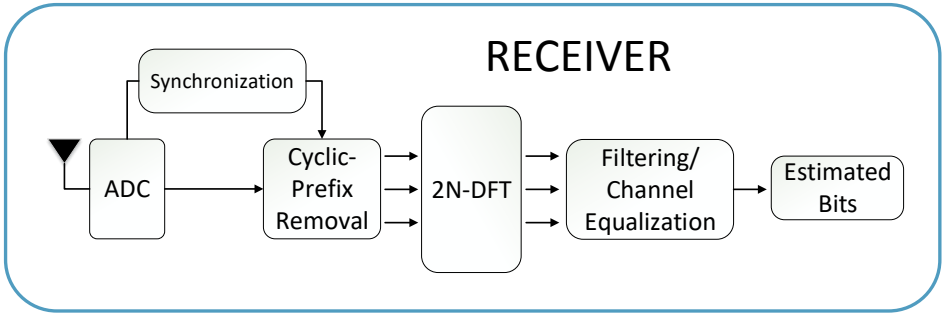
\+ Simpler synchronization

Candidate Techniques

- ✓ Filter Bank Multicarrier Modulation [SIOHAN, 2002]
- ✓ Generalized Frequency Division Multiplexing [FETTWEIS, 2009]
- ✓ Filtered-OFDM [ABDOLI, 2015]
- ✓ Zero-tail DFT-spread-OFDM [BERARDINELLI, 2013]
- ✓ Universal Filtered Multi-Carrier [VAKILIAN, 2013]
- ✓ …

Implementation Perspective



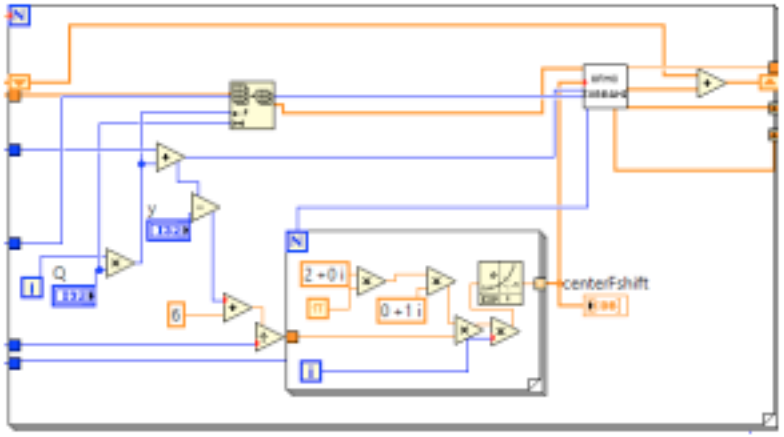


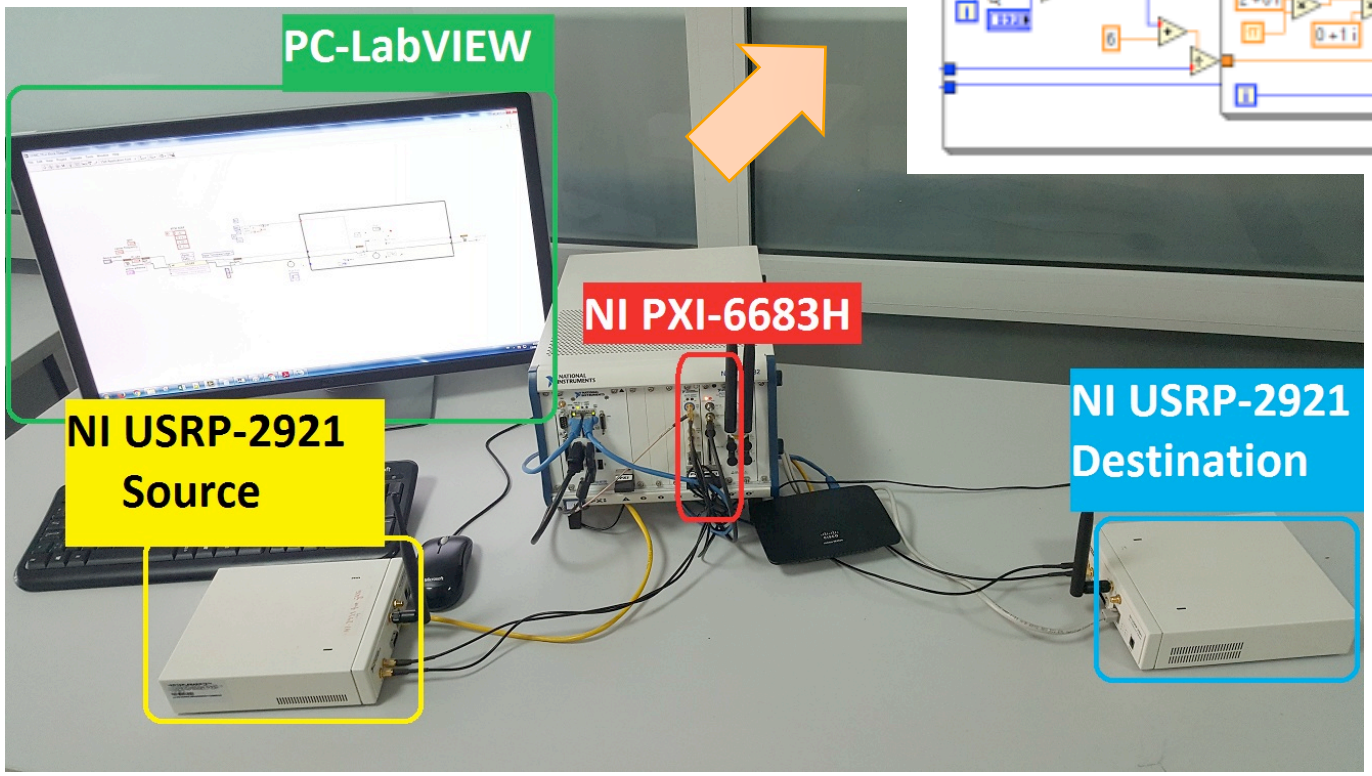
A good compromise: UFMC

- ☑ Better control of sidelobe levels/interference
- ☑ Robustness to syncronization sensitivity:

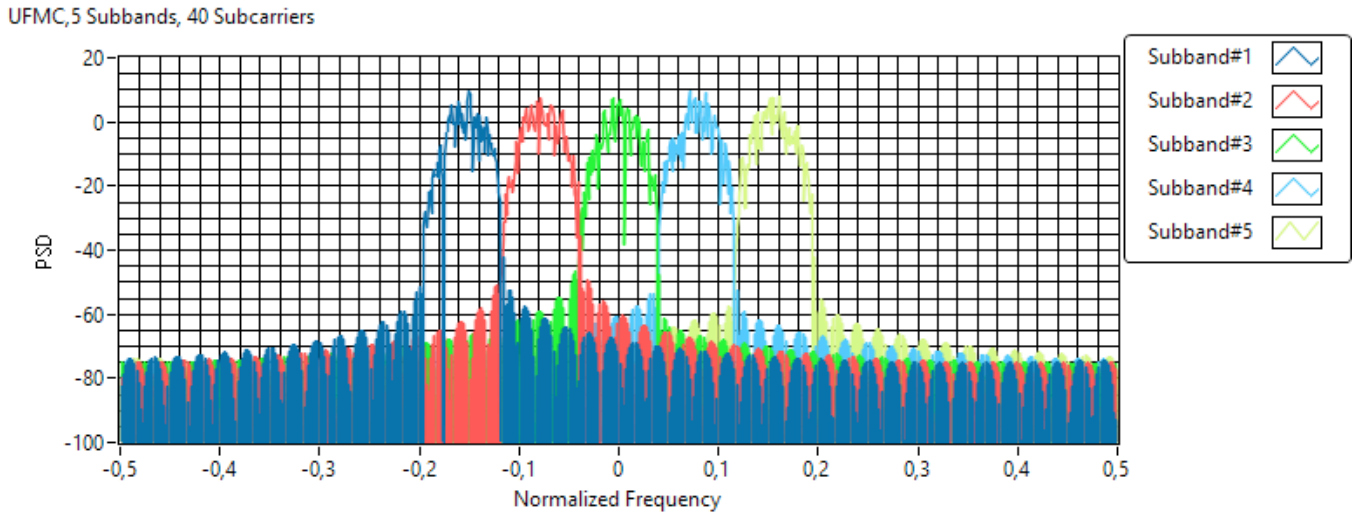
  Carrier Frequency Offset/Timing Offset

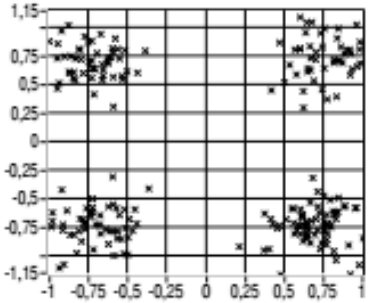
SDR Testbed


centerFshift

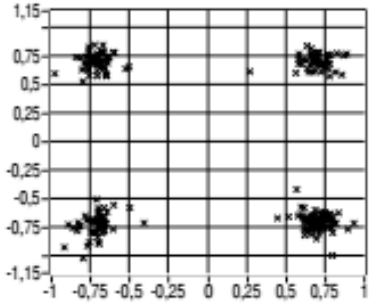

PC-LabVIEW
NI PXI-6683H
NI USRP-2921
Source
NI USRP-2921
Destination

Measurement Results





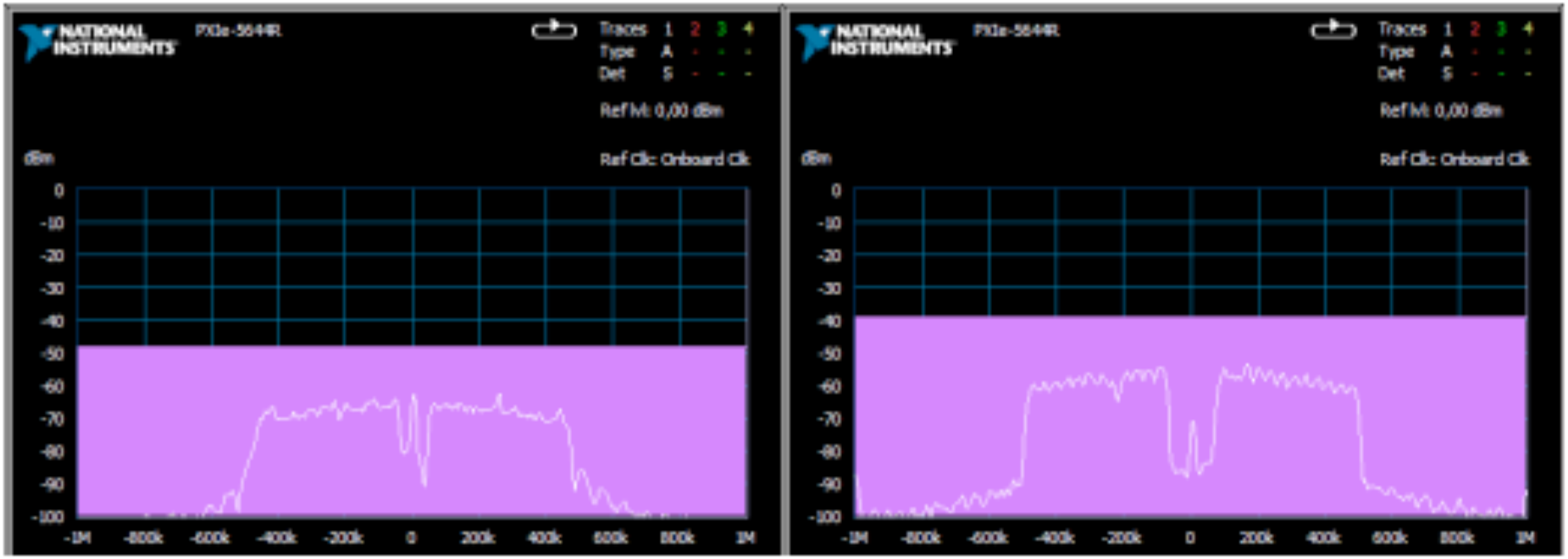
(a) OFDM



(b) UFMC

Gain	Waveform	EVM	BER
1 dB	OFDM	34.96%	2.5×10^{-3}
	UFMC	18.50%	3.6×10^{-4}
3 dB	OFDM	30.08%	6.6×10^{-4}
	UFMC	17.07%	1.9×10^{-4}
6 dB	OFDM	24.97%	4.2×10^{-4}
	UFMC	15.18%	9.5×10^{-5}

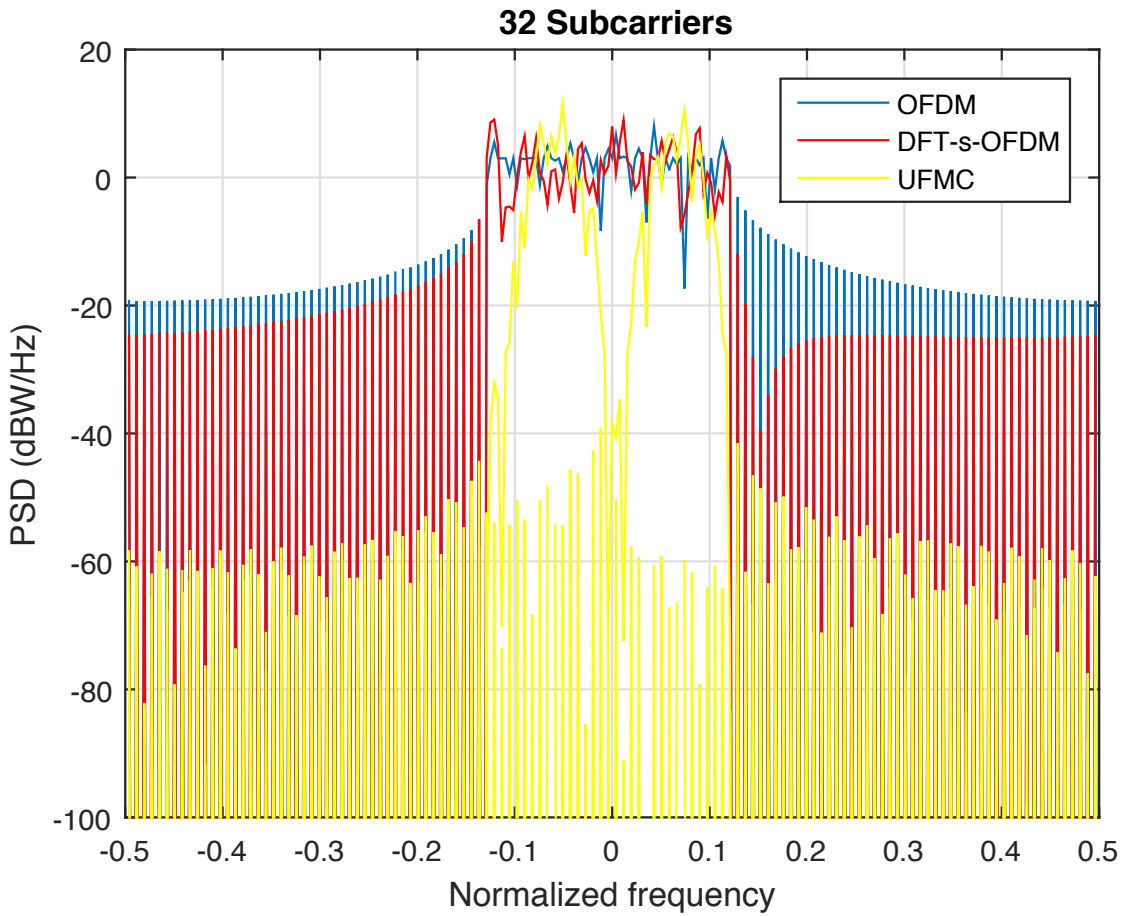
Sidelobe levels (1/2)



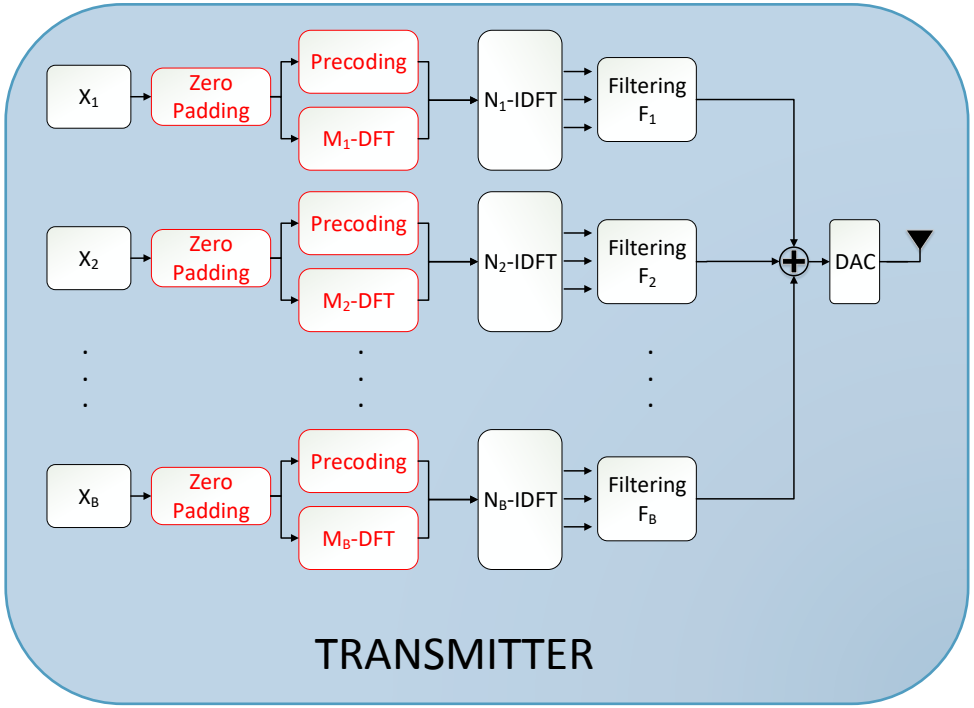
(a) OFDM signal.

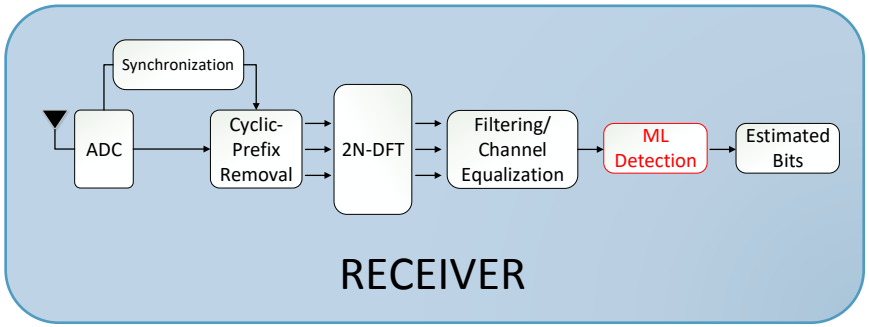
(b) UFMC signal.

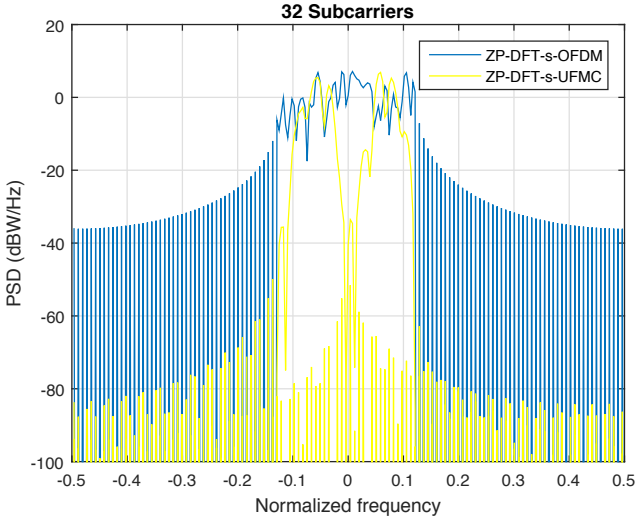
Sidelobe levels (2/2)



Further Improvements







Summary

1. OFDM & OFDMA are proven techniques
2. Dense networks may require more flexible waveform design
3. UFMC is a good option in terms of its flexibility

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Questions?

Thank you for you attention!

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