System Design Considerations for an Analog Frontend Receiver in Cognitive Radio Applications

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Outline

- Cognitive Radio Networks
- Receiver Design Considerations
- Receiver Scenario
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- References

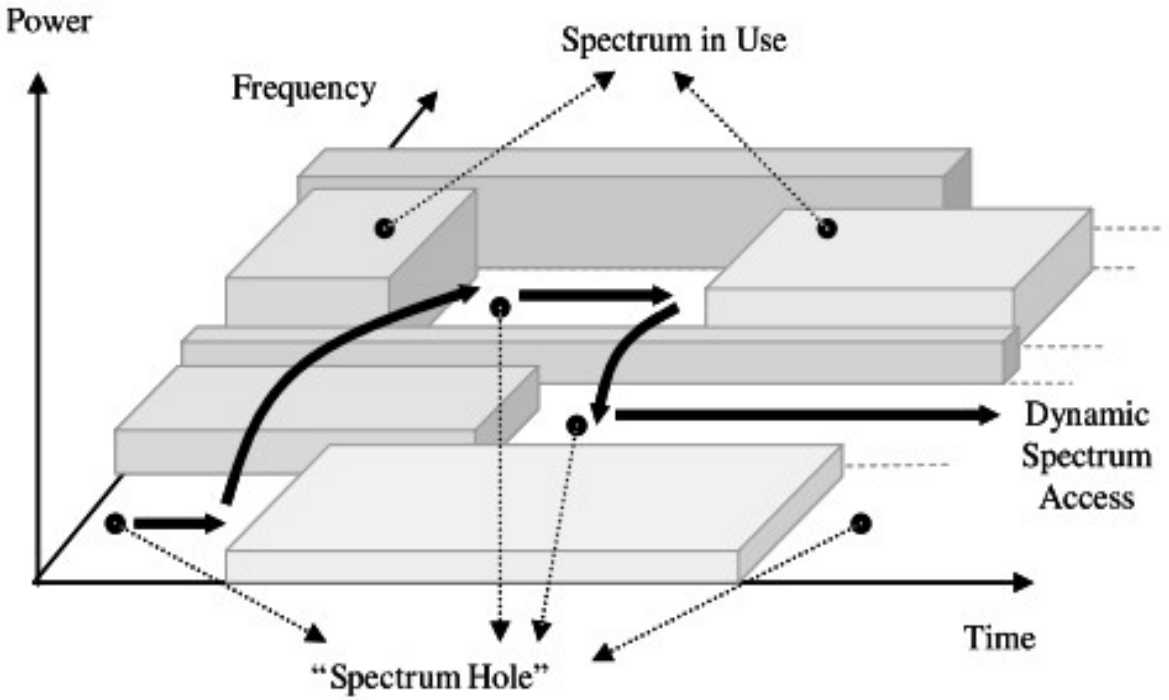
Cognitive Radio Networks

- Federal Communications Commission (FCC) opened licensed TV bands for unlicensed broadband operations to enable rural areas access in 2004 [1]

- IEEE 802.22 Working Group - Wireless for Regional Area Networks (WRAN) in 2011 [2]
  - First proposed implementation for CR networks
  - TV unused frequencies (*white spaces*)
  - Network has to protect incumbent TV and wireless microphone users

Cognitive Radio Networks

- CR can adapt to the environment



[3]

IEEE 802.22

TABLE - IEEE 802.22 Receiver Parameters [2]

Parameters	Specification	Remark
Frequency range	54 ~862 MHz	
Channel Bandwidth	6, 7, or 8 MHz	
Data rate	4.54 to 22.69 Mbps	For QPSK 1/2 and 64QAM 5/6
Modulation	QPSK, 16QAM, 64 QAM	
Multiple Access	OFDMA with 2048 FFT Size	
Cell Coverage	17 to 33 km	

Receiver Design Considerations

- For extension of frequency band
  - from 54 MHz to 4 GHz

- Main aspects for the receiver
  - Noise Figure
  - Sensitivity
  - Linearity (in the complete band)
  - Dynamic Range

Receiver Design Considerations

- Sensitivity

$$S = noise + NF + SNR_o + M_{rx} + M_{interf} + M_d$$

Table - Normalized SNR per Modulation [2]

Modulation - FEC rate	SNR for AWGN channel (dB)	Multipath channel (dB)
CDMA	1.2	5
QPSK, rate:1/2	4.3	8.1
64 QAM, rate:5/6	20.9	40.4

Receiver Design Considerations

- Linearity
  - Compression point for the OFDM using QAM modulation is specified with an Input Back-Off of 12 dB [9].

$$P1dB = Pin_{max} + PAR$$

Receiver Design Considerations

TABLE - Receiver Top Level specifications

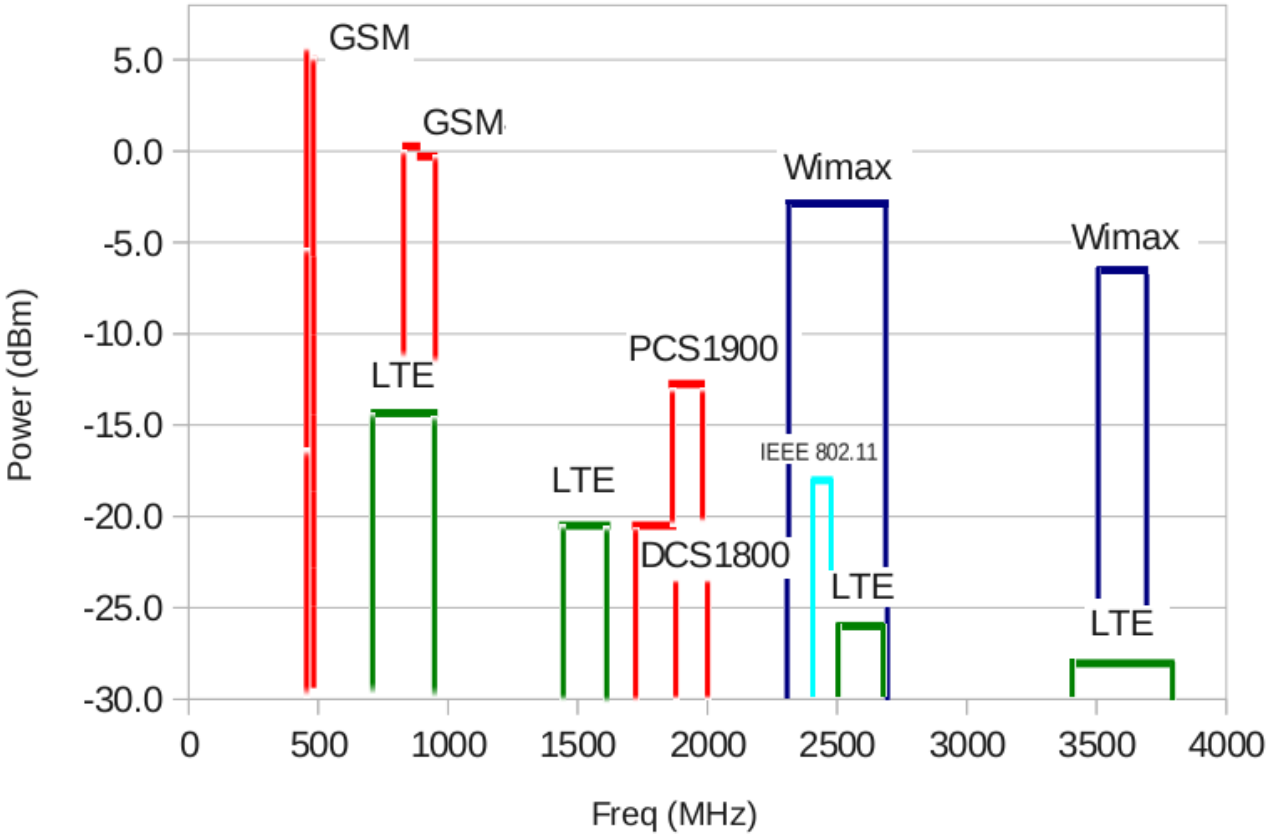
Parameter	Specification	Remark
Sensitivity (dBm)	-91.0 -87.7 -55.2	CDMA QPSK:1/2 FEC 64-QAM: 5/6 FEC
Noise Figure (dB)	6	*For CPE users*
Maximum Input Power (dBm)	-8	*To be perceived at the ADC to accommodate interferers.*
P1dB (dBm)	-29.8	
IIP3 (dBm)	-19.8	

Receiver Scenario

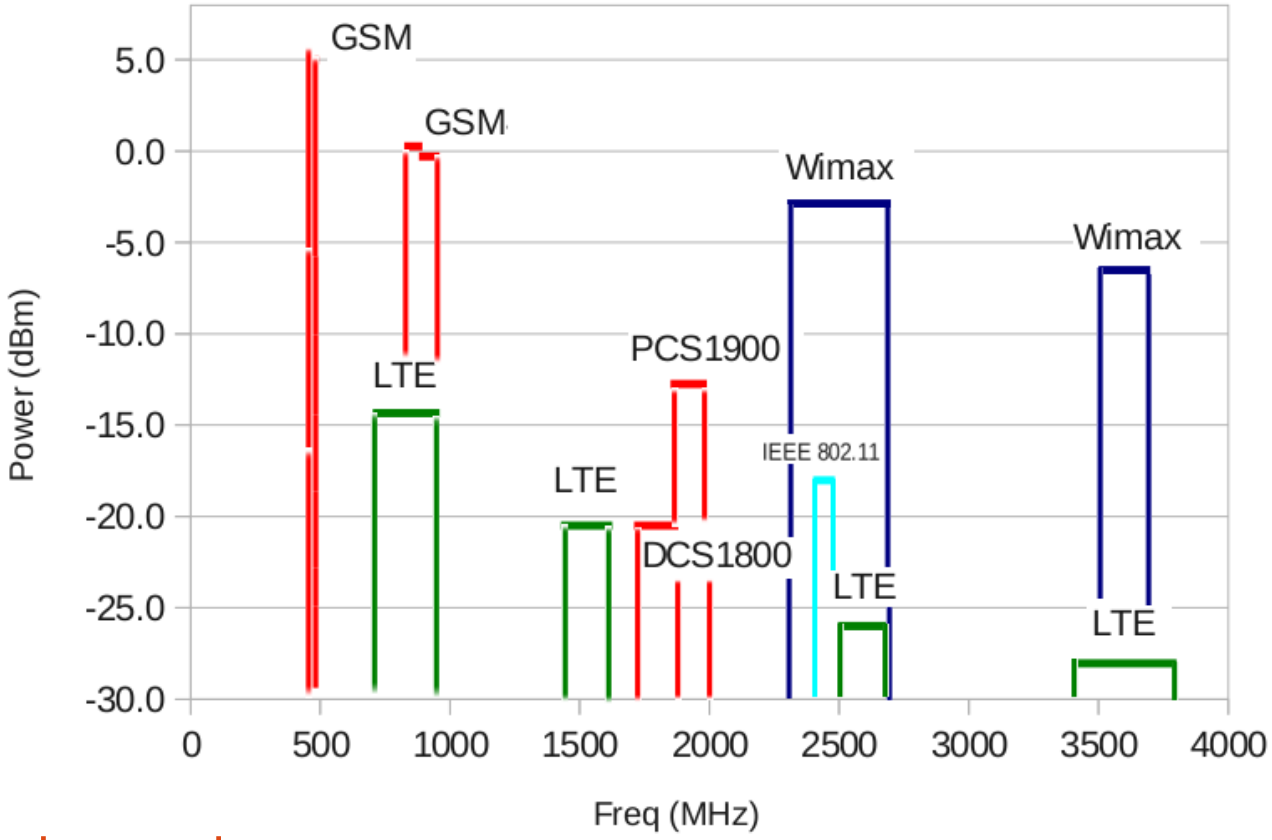
TABLE - Technologies inside the spectrum scope

Standard	Frequency Range (MHz)	BW(MHz)	Data rate (Mbps)
IEEE 802.22 [2]	54 - 862	6, 7, 8	22.69
EDGE [5]	380 - 1900	0.2	0.06
WCDMA [5]	800 - 2600	5	14.4
LTE [6]	800 - 2600	20	173/86
IEEE 802.11 [7]	2400 - 2483.5	22	54
IEEE 802.16 [7]	2300 -3500	10, 20	21

Interferers in the Spectrum Scope



Interferers in the Spectrum Scope



Linearity requirement due to intermodulation

$$IIP3 = Pbl + 1/2\left(Pbl - P_{IM,i}\right)$$

Conclusions

- This paper presented a brief overview of the cognitive radio standard IEEE 802.22.
- Sensitivity, noise figure and linearity

  are the main requirements for the receiver top level design.
- IIP3 is the tougher specification when defined by the receiver scenario.

References

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