Theoretical Specification of a Spectrum Sensing Receiver for Cognitive Radio

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Outline

I. Introduction

II. Signal-to-Noise Ratio

III. Sensitivity and Noise Figure

IV. Linearity

V. Conclusion

Introduction

- The increasing spectrum utilization and its fixed band allocation will lead to a spectrum scarcity. [1]
- Spectrum occupation surveys observed that bands of the spectrum are severely underutilized. [2,3]
- The Cognitive Radio (CR) allows for secondary users to use the vacant channels. [4]
- CR needs a trustful and fast spectrum sensing (SS).

Goals

- Theoretical calculation of specification for SS receiver.
- First steps in SS receiver circuit design.
- This SS receiver should be multistandard (IEEE 802.22, Wimax and LTE) and wideband (50MHz to 3.8GHz).
- And also, this SS receiver should comply with Energy Sensing.

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Signal-to-Noise Ratio I

- The signal-to-noise ratio (SNR) desired for a spectrum sensing (SS) receiver is determined by detection theory.

- **Detection probability (P_D):** Probability of classifying an occupied channel as occupied. In other words, found the signal. [7]

- **False alarm probability (P_{FA}):** Probability of classifying a vacant channel as occupied. [7]

Signal-to-Noise Ratio II

- If T > γ, the channel is considered occupied, otherwise the channel is considered vacant. [8]

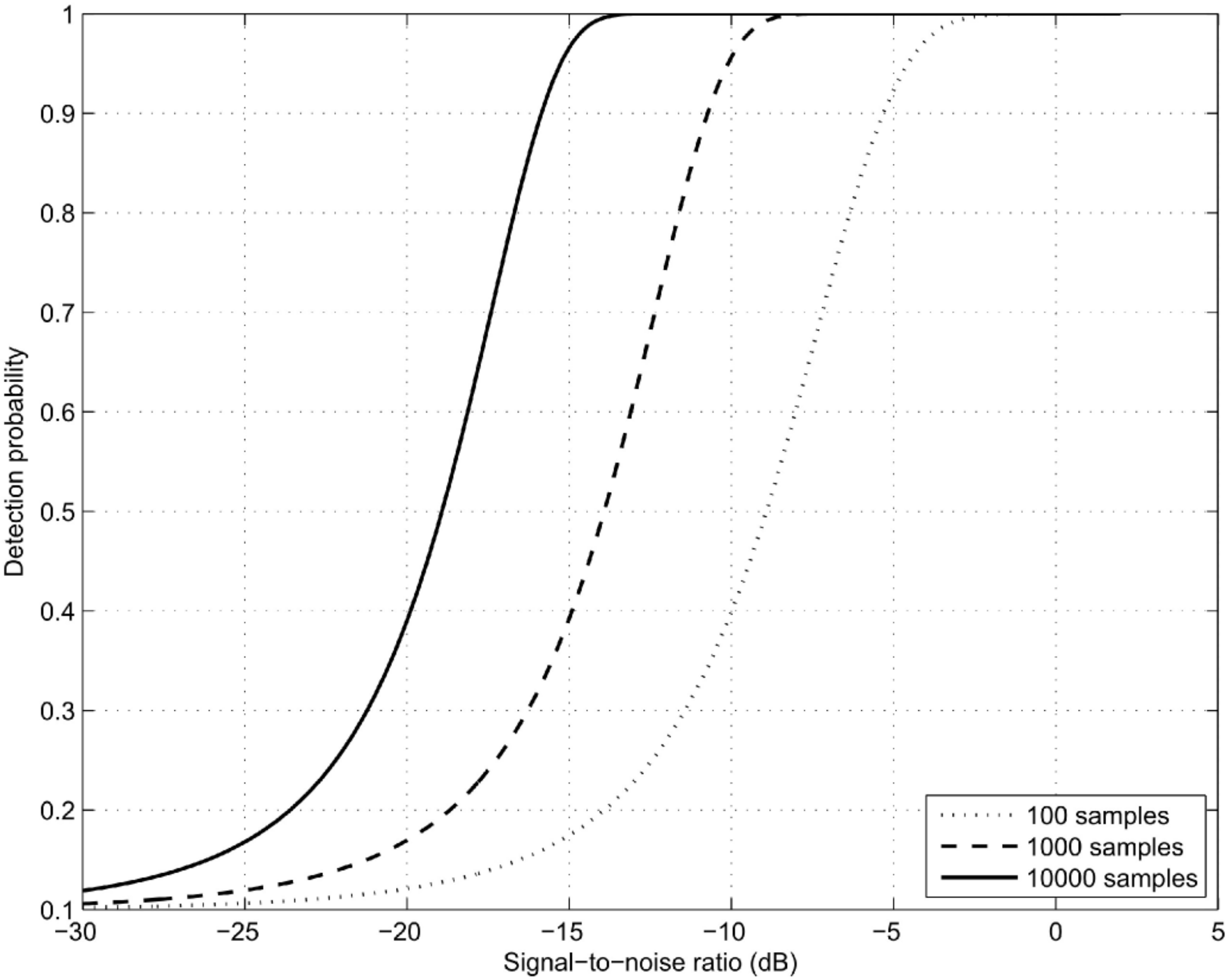
$$T = \sum_{n=1}^{M} y(n) \cdot y^{*}(n) \quad [8]$$

$$\gamma = P_N \left(1 + \frac{Q^{-1}(P_{FA})}{\sqrt{M}} \right) \quad [8]$$

- In [8] is defined,
  - $P_D \geq 90\%$
  - $P_{FA} \leq 10\%$

$$P_D = 1 - Q\left(\sqrt{M} - \frac{\sqrt{M} + Q^{-1}(P_{FA})}{SNR + 1} \right) \quad [8]$$

Signal-to-Noise Ratio III



- A SNR of -10dB is assumed for the subsequent analysis.
- P_D>90% for 1000 samples.

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Sensitivity and Noise Figure I

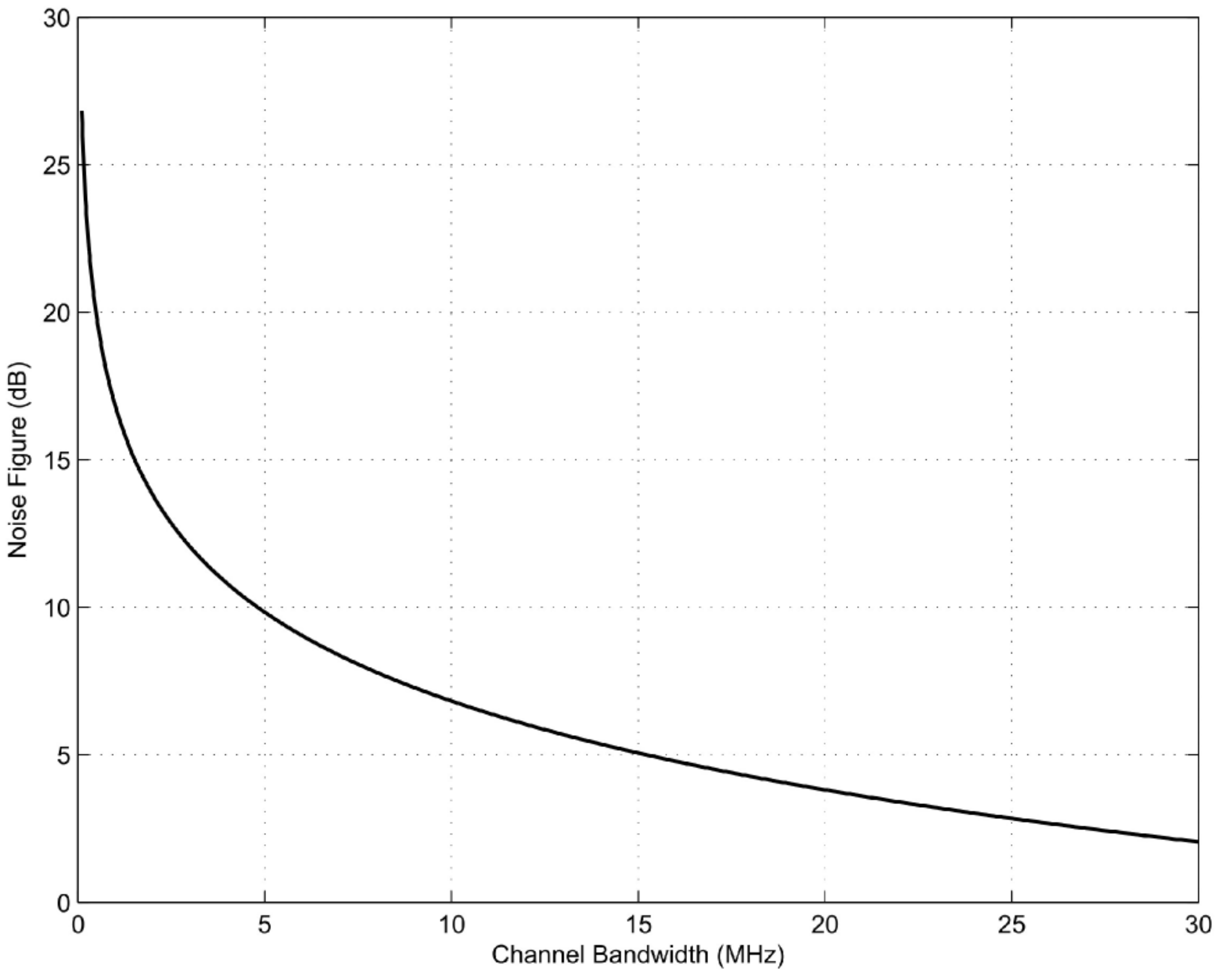
- Sensitivity is the smallest signal power that a receiver can detect with “acceptable quality”, which means a sufficient SNR. [9]

$$P_{sens} = -174 + 10 \cdot \log(B) + NF + SNR_{min} + \mathrm{IM}$$

- Sensitivity values for spectrum sensing (SS) application are:
  - -114dBm TV signals and wireless microphones. [8]
  - -116dBm for IEEE 802.22 signal. [8]
  - -125dBm for Wimax and LTE.

Sensitivity and Noise Figure II

- P_{sens} = -125dBm
- SNR_{min} = -10dB
- IM = 2dB
- NF = 3.83dB *for B = 20MHz*



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Linearity I

- OFDM/OFDMA systems exhibit a large amplitude variation which is measured by the peak-to-average ratio (PAR).
- Compression will be the most harmful nonlinearity. [9]
- 1dB compression point (CP) requirement depends on PAR considered.

Linearity II

$$PAR_{max} \leq 2 \cdot \ln(N)$$ [12]

$$CP = P_{inmax} + PAR$$ [5,6,9]

$$IIP3 \approx CP + 9.6$$ [9]

	Number of subcarriers (N)	PAR (dB)	Pin,max (dBm)	CP (dBm)	IIP3 (dBm)
IEEE 802.22	1680 [8]	14.85	-41 [6]	-26.15	-16.55
Wimax	1680 [10]	14.85	-30 [10]	-15.15	-5.55
LTE	1200 [11]	14.18	-25 [11]	-10.82	-1.22

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Conclusion

- Linearity is the major challenge for SS receiver circuit design.

- Noise figure becomes a constraint if channel bandwidth and sensitivity are increased.

Thank you!

Any questions?

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