Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Alternative UWB System Physical Layer Proposal for 802.15.4a
Date Submitted: January 4, 2005
Source: Robert Qiu, Nan Guo
Company: Tennessee Technological University
Address: Cookeville, TN 38505
Voice: 931-372-3847
E-Mail: rqiu@tntech.edu
Re: Response to Call for Proposals
Abstract: This document presents a preliminary alternative physical layer proposal for 802.15.4a
Purpose: Proposal for 802.15.4a standard

Contents

1. Introduction

- Cost is a major concern
- Good suboptimal candidates include
  - Transmitted Reference (TR) and
  - Autocorrelation Detection (ADC) based on differentially encoding

- ADC not only eliminates the use of expensive waveform estimator at the receiver, but also is more efficient than TR.

2. Modulation and Coding

- Differential binary PSK (DBPSK)
  - implementation simplicity
  - simple receiver structure based on differential detection
- Multi-rate channel encoders (convolutional code and/or turbo code): support variable data rates under different channel conditions

3. Multiple Access

- Asynchronous DS-CDMA to support multiple access ability
- Advantages
  - does not have to use a large number of precise delay lines for de-spreading purpose at the receiver
  - can be less sensitive to timing since only rough pulse (chip) boundary timing is needed
- DS-CDMA + CSMA-CA can be an alternative multiple channel access solution to support vast number of users

4. Spectrum

- 3 dB bandwidth: minimal 500 MHz
- Frequency range limits: 800 MHz – 10.6 GHz

5. Transmitter

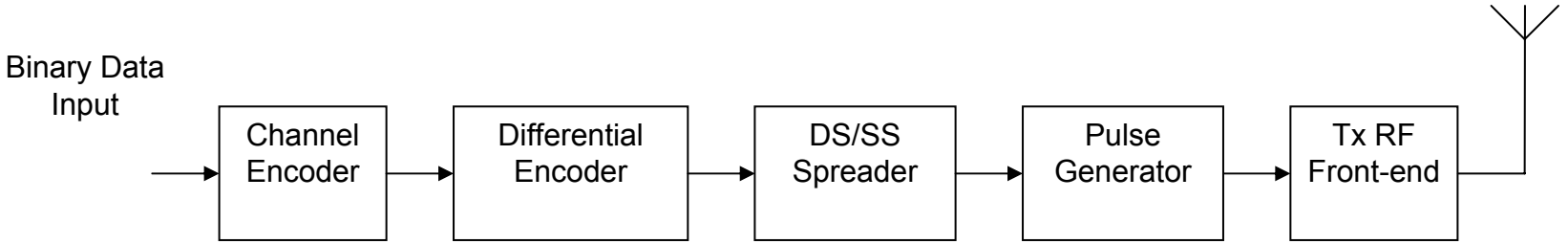


Fig.1. Transmitter structure

6. Receiver

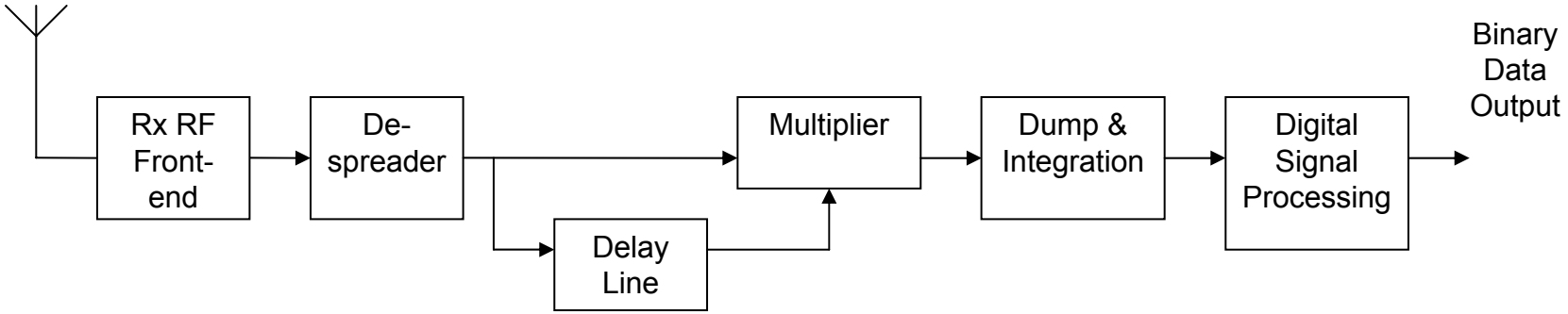


Fig.2. Receiver structure

7. Link Budget

Parameters	Values
Raw bit rate Rb	1 Mbps
Average Tx power	- 13.71 dBm
Tx antenna gain	0 dBi
Center frequency	4.125 GHz
Path loss at 1 m	44.75 dB
Path loss at 30 m	74.29 dB
Rx antenna gain	0 dBi
Average Rx power	- 88 dBm
Thermal noise power per bit: -174 + 10*log10(Rb)	- 114 dBm
Noise figure	7 dB
Total noise power per bit	- 107 dBm
Minimal required *Eb/No*	12 dB
Implementation loss	4 dB
Link margin	3 dB
Proposed minimal Rx sensitivity	- 91 dBm

8. Backup Technologies

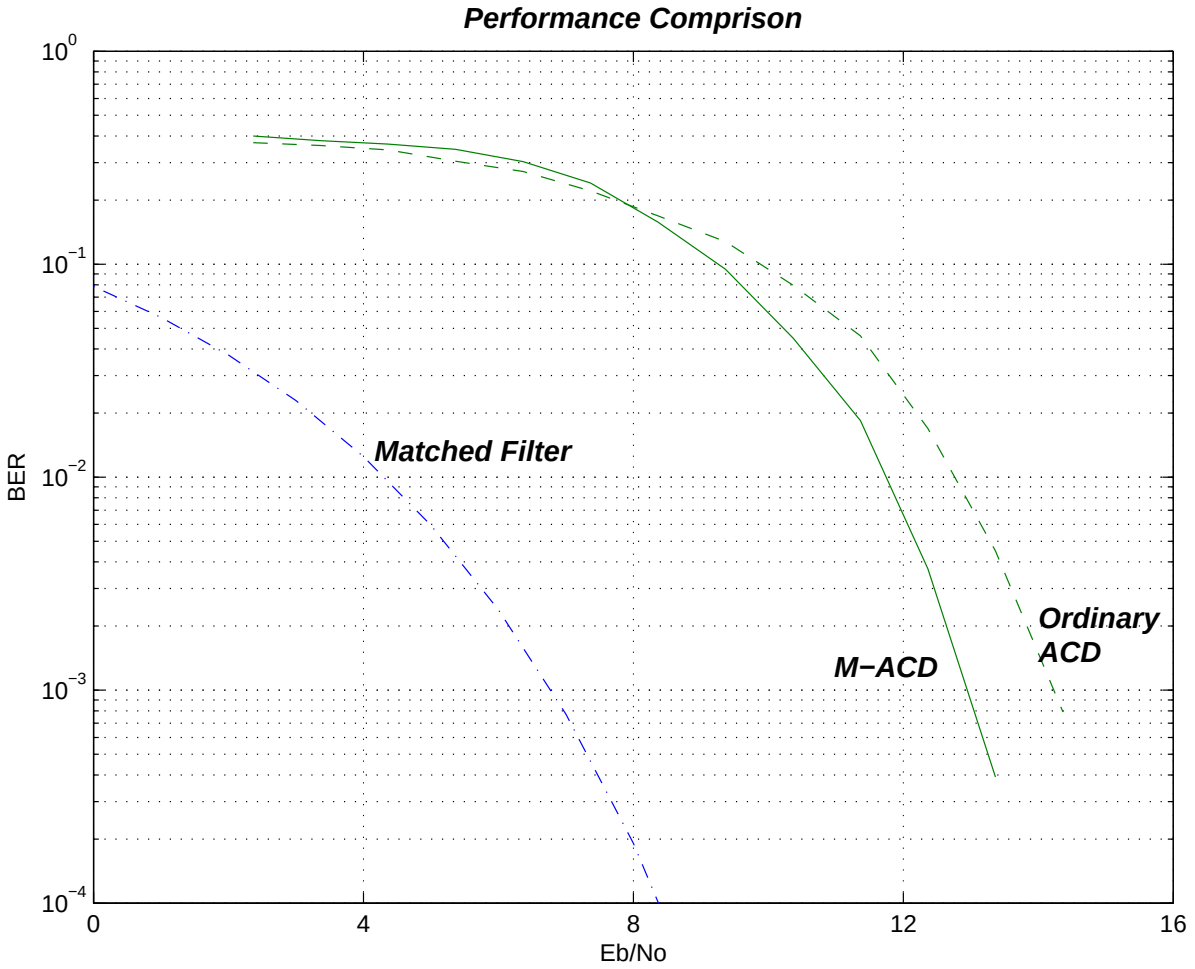
- Reduced bit quantization
- Reference enhancement
- Multiple symbol detection
- Gating/adaptive integration

9. Example and Performance

- Raw bit rate: 1 Mbps
- Spreading code length: 16 chips
- Pulse repetition frequency (PRF): 16 MHz (pulse repetition interval = 62.5 ns)

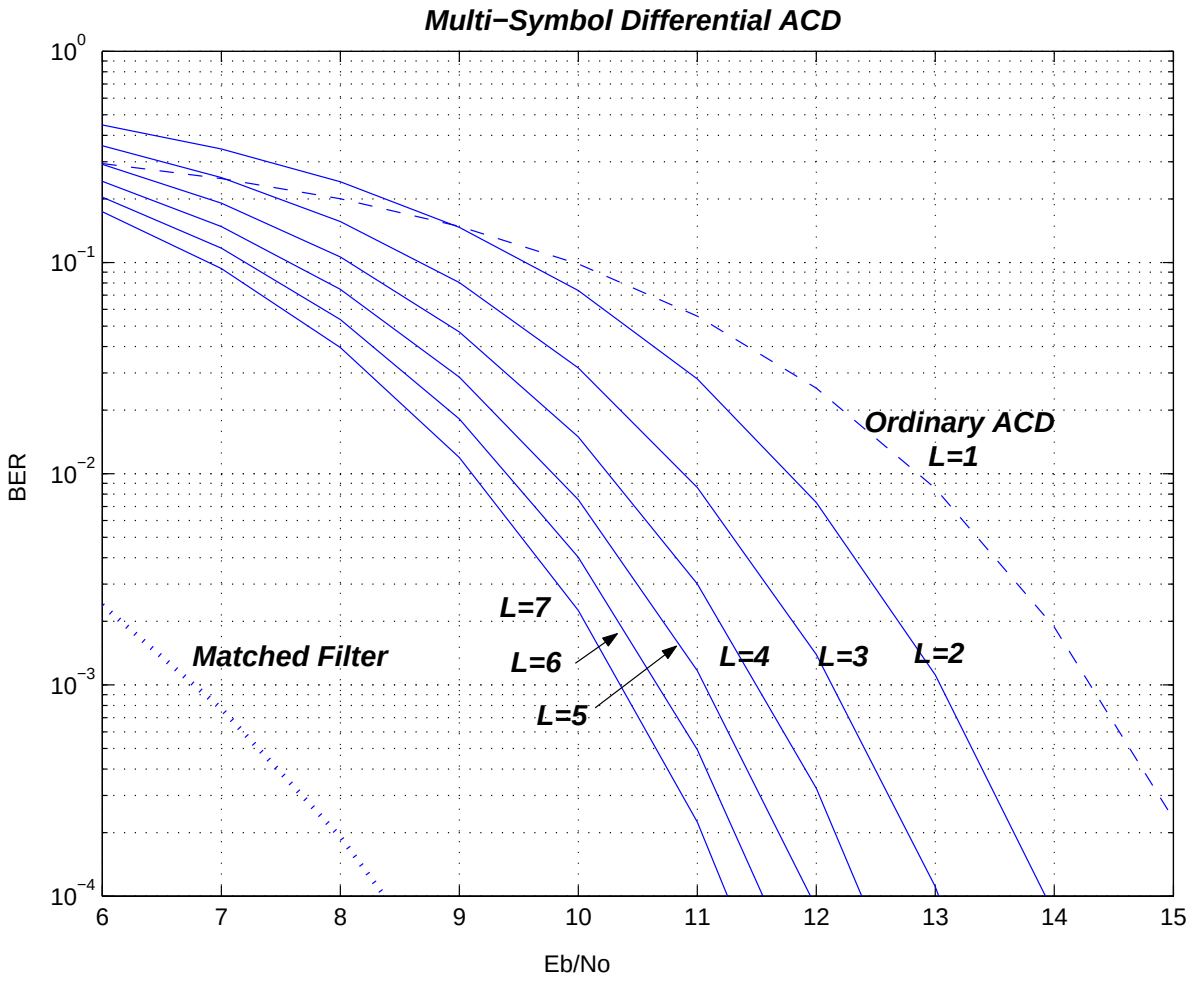
9. Example and Performance (cont')

Performance comparison of ordinary ADC and ACD with reference enhancement based on decision feedback



9. Example and Performance (cont')

Performance of multi-symbol differential ACD



10. Conclusion

- A physical layer architecture for low data rate UWB communications has been proposed.
- features:
  - No need for channel estimation and waveform estimation
  - Make full use of all the multipath energy
  - Timing requirement is very low
  - Flexible in accommodating variable data rate and multiple users
  - Better performance than some of schemes that use suboptimal reception techniques such as square law/envelop detection
  - Potential to overlay with existing systems
  - Enabling to combining with some enhancement techniques to improve performance further
- Further details regarding pulse shape and spectrum, channel control coding, spreading codes, and frame structure, etc., need to be specified in the future.

Reference

1. IEEE 802.15.4a , “Status of models for UWB propagation channel,” IEEE 802.15.4a Channel Model (Final Report), Sept. 2004. Available at http://www.ieee802.org/15/pub/TG4a.html
2. R. C. Qiu, H. P.Liu , X. Shen, and M. Guizani, “Ultra-Wideband for Multiple Access,” IEEE Communications Magazine, Feb. 2005. Available at http://iweb.tntech.edu/rqiu/Publication/Journal%20papers.htm
3. R. C. Qiu, “A Generalized Time Domain Multipath Channel and Its Application in Ultra-Wideband (UWB) Wireless Optimal Receiver Design: System Performance Analysis,” IEEE Trans. Wireless Communications, to appear. Available at http://iweb.tntech.edu/rqiu/Publication/Journal%20papers.htm
4. R. C. Qiu, “A Theoretical Study of the Ultra-Wideband Wireless Propagation Channel and Optimum UWB Receiver Design”, *IEEE Journal on Selected Areas in Communications (JSAC),* **special issue on UWB multiple access communications**, Vol. 20, No. 12, Dec. 2002.
5. N. Guo and R. C. Qiu, “Improved autocorrelation receivers based on multiple symbol differential detection for UWB communications,” IEEE Vehicular Technology Conference 2005 (VTC’05), Accepted for publication, Dec. 2004.