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Real-time FPGA realization of an UWB transceiver physical layer

Darryn W. Lowe
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REAL-TIME FPGA REALIZATION OF
AN UWB TRANSCEIVER PHYSICAL LAYER

A thesis submitted in fulfilment of the
requirements for the award of the degree

MASTER OF ENGINEERING – RESEARCH

from

UNIVERSITY OF WOLLONGONG

by

Darryn W. Lowe, BEng (Hons 1)

School of Electrical, Computer and Telecommunications Engineering

2005

I, Darryn W. Lowe, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Master of Engineering – Research, in the School of Electrical, Computer and Telecommunications Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Darryn W. Lowe
14 November 2005

Contents

1	Introduction	1
1.1	Design Methodology	3
1.2	Contributions	5
2	A Novel UWB PHY	9
2.1	MCIDS	10
2.2	CCDM	13
2.3	Specification	19
2.3.1	Preamble	21
2.3.2	SFD	22
2.3.3	PHY Header Definition	22
2.3.4	HCS	24
2.3.5	Scrambling	24
2.3.6	Symbol Mapping	25
2.3.7	Prespreading	27
2.3.8	CCDM	27
2.3.9	Pilot Insertion	27
2.3.10	MCIDS Spreading	29
2.3.11	Spectral Mask	29
3	Transmitter	31
3.1	Top-Level Architecture	31

3.2	Bus Interfacing	34
3.2.1	Control Word	34
3.2.2	Status Word	37
3.2.3	Packet Buffer	38
3.3	Header Preparation	42
3.3.1	Header Timing	43
3.3.2	Header Check Sum	45
3.3.3	Scrambler	45
3.4	Symbol Creation	46
3.4.1	Symbol Buffer	47
3.4.2	Constellation Mapping	55
3.5	CCDM	59
3.5.1	Spreading Architecture	62
3.5.2	Control	66
3.5.3	Separating I/Q Components	71
3.6	MCIDS	71
3.6.1	Buffering	72
3.6.2	Pilot Insertion	76
3.6.3	Preamble Generation	77
3.6.4	Interleaving	79
3.6.5	Spreading	83
3.6.6	Transmitted Signal	83
4	Receiver	87
4.1	MCIDS Despreading	89
4.1.1	MCIDS RAKE	91
4.1.2	Frame Detection	105
4.1.3	Equalization	111
4.1.4	Automatic Gain Control	115
4.1.5	DetectSFD	117

4.2	CCDM Demodulation	119
4.2.1	Removing Pilots	119
4.2.2	Buffering	121
4.2.3	Despreading	122
4.3	Constellation Demapping	130
4.3.1	I/Q Buffer	130
4.3.2	Demapping	134
4.4	Header Processing	138
4.4.1	Data Rate Management	138
4.4.2	Descrambling	138
4.4.3	Header Validation	139
4.5	Bus	139
4.5.1	Packet Buffer	140
4.5.2	Control Registers	141
5	Analysis	145
5.1	Test Environment	145
5.1.1	RF Front-end Models	145
5.1.2	Channel Models	148
5.1.3	MAC Models	150
5.2	Performance	155
5.2.1	AWGN	155
5.2.2	Multipath Channel	157
5.3	Sensitivity to Word Length	163
5.4	Complexity	164
5.4.1	Device Selection	164
5.4.2	Synthesis Results	165
6	Conclusions	167
A	Transmitter Models	171

B Receiver Models	187
C Parametrization Scripts	209
C.1 Constants	209
C.1.1 Global Constants	209
C.1.2 Parameters	211
C.2 ROMs	214
C.2.1 Transmitter CCDM Codeset ROM	214
C.2.2 Receiver CCDM Codeset ROM	215
C.2.3 Receiver MCIDS Codeset ROM	215
C.2.4 Receiver Synchronization Codeset ROM	216
C.2.5 Receiver RAKE Correlator Interleaver	216
D Simulation	219
D.1 Functional Blocks	219
D.1.1 CRC	219
D.1.2 Scrambler	220
D.1.3 Constellation Mapping	220
D.1.4 CCDM	223
D.1.5 Pilots	225
D.1.6 Preamble	226
D.1.7 MCIDS	226
D.2 Simulation Framework	230
D.2.1 Top-Level Simulation	230
D.2.2 End-to-End Link Model	231
D.2.3 Packet Constructor	232
D.2.4 Transmitter Baseband Model	233
D.2.5 Multipath Channel Model	233
D.2.6 Receiver Front-end Model	235
D.2.7 Receiver Baseband Model	236

List of Tables

2.1	Example of an MCIDS Spread Signal for $M = N = 4$	12
2.2	Example of MCIDS Despreading for $M = 4$	13
2.3	Preamble Sequence	22
2.4	SFD Sequence	22
2.5	PHY Header Definition	23
2.6	Data Rate Mappings for PHY Header	23
2.7	Initial Values for PRBS	25
2.8	Normalization Constants for Symbol Constellations	25
2.9	Prespread Codes	27
2.10	Transceiver Spectral Mask	29
3.1	Example of Buffer Signal Mask Generation	41
3.2	Derivation of Header Control Signal Constants	45
3.3	Data Bits for Modulation Types	49
3.4	Relationship between Symbol Density and FIFO Reads	54
3.5	Constellation Mapping for BPSK & QPSK	58
3.6	Construction of <i>Out_Code</i>	69
3.7	Calculation of MCIDS Buffer Read Address	76
3.8	BPSK Modulation of Preamble Bits	78
4.1	Adder Coefficient Modification for RAKE Finger Correlator	98
4.2	MCIDS Code ROM	104
4.3	Synchronization Constants for RAKE Finger Correlators	107

4.4	State Machine in CCDM Control	126
4.5	CCDM Despreading States for Delay Line Registers	126
4.6	Adder Coefficients for 8-Chip CCDM Correlators	128
4.7	CCDM 8-Chip Code ROM	129
5.1	Summary of IEEE UWB Channel Model Properties	149
5.2	Main Features of XC2VP70 FPGA	164
5.3	Summary of Utilization of XC2VP70 FPGA	165
5.4	Detailed Synthesis Results	166

List of Figures

1.1	Transceiver Development Methodology	3
2.1	Transceiver Block Diagram	10
2.2	Example of CCDM Sequence Set for L=28 and K=2	17
2.3	PHY Frame Format	20
2.4	Example of Spreading Process for PHY Header	21
2.5	Bits-to-Symbol Mappings for BPSK, QPSK, 16-QAM and 64-QAM	26
2.6	Codeset Definitions for CCDM and MCIDS	28
2.7	Insertion of Pilots	29
2.8	FCC Emissions Limit on UWB and Transceiver Spectral Mask	30
3.1	Tx Overall Timing	33
3.2	Transmitter Scrambler & HCS Timing	42
3.3	Tx Map	48
3.4	Timing of Tx-Map-Buffer-Group ^{A.22} Block	51
3.5	FIFO Refilling	52
3.6	Counter Synchronization	57
3.7	Impact of Pre-spreading on Symbol Timing	58
3.8	Timing of Transmitter's CCDM Spreading	61
3.9	Architecture of CCDM Spreading	64
3.10	Tx CCDM Spreader Timing – Load Cycle	68
3.11	Tx CCDM Spreader Timing – Write Cycle	70
3.12	Tx MCIDS Buffer Addressing	73

3.13	Impact of Pilots on Tx MCIDS Addressing	75
3.14	Tx MCIDS Interleaver ASR Control	81
3.15	Tx MCIDS Interleaver ASR Addressing	82
3.16	Transmitted Signal for a QPSK packet with a payload of 384 bits	84
4.1	Receiver State Machine	88
4.2	Top-Level MCIDS Despreading Timing	90
4.3	Architecture of RAKE Receiver	92
4.4	Worst-Case 64-Finger RAKE Buffer Register Requirements	94
4.5	Buffer Register Requirements for 32 RAKE Fingers	95
4.6	Architecture of RAKE Finger Correlator	97
4.7	MCIDS Despreading Control Timing	103
4.8	RAKE Buffer for Preamble Correlation	106
4.9	Frame Detection and Synchronization Timing	109
4.10	Initialization of Channel Coefficient Timing	113
4.11	Update of Channel Coefficient Timing	116
4.12	Pilot Removal in Rx-CCDM-RemovePilots ^{B.29}	120
4.13	Pilot Removal in Rx-CCDM-Buffer ^{B.30}	123
4.14	Timing of Rx-CCDM ^{B.28}	124
4.15	Control of Load Cycle in Rx-CCDM-Control ^{B.32}	125
4.16	Architecture of CCDM 8-Chip Correlator	127
4.17	Address Generation in Rx-DeMap-Addr ^{B.39}	133
4.18	Compensating for Sub-rate Modulations	136
4.19	Receiver Packet Buffer Writes in Rx-Bus-Parallel-BitCnt ^{B.59}	142
5.1	Example RLC Circuit for Transmit Butterworth Filter	146
5.2	Spectral Mask and Transmitted Power Spectral Density	147
5.3	Matched Filter Performance	148
5.4	Transmitter MAC State Machine Model	152
5.5	OPB Bus Transactions During Transmission of a Packet	153

5.6	Receiver State Machine	154
5.7	Theoretical BER vs. $\frac{Eb}{N0}$ in AWGN.	156
5.8	Simulated BER vs. $\frac{Eb}{N0}$ in AWGN.	157
5.9	Simulated BER vs. $\frac{Eb}{N0}$ in CM1.	158
5.10	Simulated BER vs. $\frac{Eb}{N0}$ in CM2.	159
5.11	Simulated BER vs. $\frac{Eb}{N0}$ in CM3.	160
5.12	Simulated BER vs. $\frac{Eb}{N0}$ in CM4.	161
5.13	Simulated BER vs. $\frac{Eb}{N0}$ for QPSK in all channels.	162
5.14	Simulated PER vs. ADC Bit Width.	163

List of Abbreviations

ADC	Analog to Digital Convertor
AGC	Automatic Gain Control
ASR	Addressable Shift Register
BER	Bit Error Rate
CCDM	Complementary Code Division Multiplexing
DAC	Digital to Analog Convertor
DSSS	Direct Sequence Spread Spectrum
FCC	Federal Communications Commission
FCS	Frame Check Sequence
FIFO	First-In First-Out
FPGA	Field Programmable Gate Array
HCS	Header Check Sequence
I	In-Phase
ISI	Inter-Symbol Interference
LNA	Low Noise Amplifier
LOS	Line Of Sight
LSB	Least Significant Bit
LUT	Look Up Table
MAC	Medium Access Control
MCIDS	Multicode Interleaved Direct Sequence
MPDU	MAC Protocol Data Unit
MRC	Maximal Ratio Combining

MSB	Most Significant Bit
NLOS	Non-Line Of Sight
OPB	On-chip Peripheral Bus
PAR	Place and Route
PER	Packet Error Rate
PHY	Physical Layer
PRBS	Pseudo-Random Binary Sequence
PSD	Power Spectral Density
Q	Quadrature
RAM	Random Access Memory
RF	Radio Frequency
ROM	Read Only Memory
RTL	Register Transfer Level
S-V	Saleh-Valenzuela
SFD	Start Frame Delimiter
SIFS	Short Inter-Frame Spacing
TDM	Time Division Multiplex
UWB	Ultra-WideBand

Abstract

An original ultra-wideband (UWB) physical layer (PHY) specification is developed and implemented in digital logic. The novelty of this UWB PHY is based on a combination of complementary code division multiplexing (CCDM), which yields a low-interference signal with a variable process gain, and multicode interleaved direct sequence (MCIDS) spreading, which provides an additional fixed process gain as well as multipath robustness. To operate at the high sample rates needed for UWB, the digital logic, realized in a Virtex-II field programmable gate array (FPGA), has a highly-pipelined architecture for real-time signal processing. In addition, the gate count is minimized by avoiding the use of explicit buffer memory wherever possible. The performance of the transceiver is analyzed under a variety of UWB channels and impairments. It is concluded that the proposed UWB PHY offers robust performance in real-world environments and that it is viable for use in future communication systems.

Acknowledgements

Cry havoc! And let slip the dogs of war.

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