ARAB ACADEMY FOR SCIENCE, TECHNOLOGY AND MARITIME TRANSPORT (AASTMT)

College of Engineering and Technology

Department of Mechanical Engineering

Error Performance of Low-Complexity Ultra-Wideband RAKE Receivers in Dynamic Channels

By

Marwa Mohamed Mahmoud El-Sayed

A thesis submitted to AASTMT in partial

Fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

in

ELECTRONICS AND COMMUNICATIONS ENGINEERING

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MARCH 2013

DECLARATION

إقرار الباحث

أقر بأن المادة العلمية الواردة في هذه الرسالة قد تم تحديد مصدرها العلمي وأن محتوى الرسالة غير مقدم للحصول علي أي درجة علمية أخرى، وأن مضمون هذه الرسالة يعكس آراء الباحث الخاصة وهى ليست بالضرورة الآراء التي تتبناها الجهة المانحة .

الباحث

الاسم : مروة محمد محمود السيد

التوقيع .....

DECLARATION

I certify that all the material in this thesis that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this thesis reflect my own personal views, and are not necessarily endorsed by the University.

Name : Marwa Mohamed Mahmoud El-Sayed.

(Signature) Marwa Mohamed Mahmoud EL-Sayed

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Abstract

Ultra wideband (UWB) communications uses a wide range of spectrum, typically 3.1 – 10.6 GHz, to transmit low powered (below -41.3 dB m), ultra-short (0.2 – 1.5 ns) pulses through the air. UWB technology can provide unique and attractive features, such as ultra-high-speed data rates, and ultra-fine time resolution for precise positioning and ranging. This work studies and evaluates the bit-error-rate (BER) performance of UWB time-hopping communication system with pulse position modulation (TH-PPM) as well as direct sequence pulse amplitude modulation (DS-PAM) with low-complexity RAKE reception in dynamic UWB channels. The study includes both the IEEE 802.15.3a and underground tunnels in UWB coal mine channels. The studied receivers are partial-RAKE (P-RAKE) and selective-RAKE (S-RAKE), and are compared to optimal All-RAKE (A-RAKE) receivers. Numerical results show that TH-PPM UWB and DS-PAM systems with low-complexity RAKE receivers are good candidates for communications in the IEEE 802.15.3a as well as underground and coal mine tunnels.

LIST OF ABBREVIATIONS

3G	Third Generation
AWGN	Additive White Gaussian Noise
AVCE	Audio and Video Consumer Electronics
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
CDMA	Code Division Multiple Access
DS	Direct Sequence
DSSS	Direct Sequence Spreaed Spectrum
DVD	Digital Versatile Disk
EGC	Equal Gain Combining
EIRP	Effective Isotropic Radiated Power
ETSI	European Technical Standard Institute
FCC	Federal Communication Commission
FH	Frequency Hopping
FIR	Finity Impulse Filter
FDMA	Frequency Division Multiple Access
GPS	Global Position System
GSM	Global System For Mobile
GPR	Ground Penetrating Radar
IEEE	Institute Of Electrical And Electronics Engineers
I-UWB	Impulse-Ultra Wide Band
IR	Impulse-Radio
LAN	Local Area Network
LOS	Line Of Sight
MAI	Multiple Access Interference
MC	Multi-Carrier
MRC	Maximal Ratio Combining

MUI	Multi-User Interference
NLOS	Non Line Of Sight
OFDM	Orthogonal Frequency Division Multiplexing
OOK	On-Off Keying
PAN	Personal Area Network
PCS	Personal Communication Services
PC	Personal Computer
PDP	Power delay profile
PHY	Physical Layer
PSD	Power Spectral Density
PPM	Pulse Position Modulation
PVRs	Personal Video Recorders
RF	Radio Frequency
SNR	Signal To Noise Ratio
TDMA	Time Division Multiple Access
TH	Time Hopping
UMTS	Universal Mobile Telephone System
U-NII	Unlicensed-National Information Infrastructure
UWB	Ultra Wideband
WLAN	Wireless Local Area Network
WUSB	Wireless Universal Serial Bus

LIST OF FIGURES

LIST OF SYMBOLS

$r_u(t)$	Attenuated and delayed version
α	Channel gain
B_{-10dB}	Bandwidth at -10 dB
τ	Channel delay
ε	Time shift
$n(t)$	Additive noise
B_{UWB}	Bandwidth of UWB
x	Gaussian random variable
E_{TX}	Transmitted energy per pulse
$S_m(t)$	Transmitted waveform
α_{nk}	Channel coefficient
T_{n-1}	Time of arrival of the N-Th and the (N-1)-Th clusters
T_m	Max time delay spread of the multipath channel
f_{H_10dB}	High frequency at -10 dB
f_{L_10dB}	Low frequency at -10 dB
μ_{nk}	Mean
σ_{nk}	Standard deviation
$h(t)$	Impulse response of the channel
Λ	The cluster average arrival rate

λ	The pulse average arrival rate
Γ	Power delay factor for cluster
γ	The power delay factor γ for pulse within a cluster
$\sigma\xi$	The standard deviation of the fluctuation of the channel coefficient for the clusters.
L	Path number
$n(t)$	Gaussian noise
p_e	The BER
Tp	Time resolution ratio
$r(t)$	Received signal
$\beta_k(t)$	Path response intension
σg	The standard deviation σg of the channel amplitude gain
N	Number of clusters observed at destination
a_j	Amplitude of the j-th transmitted pulse.
φ_j	Time dithering associated to the j-th pulse
T_s	Average pulse repetition period
$\sigma\zeta$	The standard deviation of the fluctuation of the channel coefficient for pulse within each cluster
N_R	Number of branches of the RAKE receiver.
ω_j	Weighting factor
T_n	Arrival time of the n^{th} cluster
K(n)	Received number of multipath in the n^{th} cluster
P_{nk}	Discrete random variable

$\beta 00$	Represents the average energy
err(t)	Signal loss
r '(t)	Captured by the a RAKE receiver
T_L	Observation interval

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CHAPTER 3 THE UWB CHANNEL AND RECEIVER

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1.3 تنظيم الرسالة

تنظيم الرسالة هو على النحو التالي : الباب الثاني يعرض خلفية علمية عن نظم الاتصال اللاسلكية فائقة الاتساع. الباب الثالث يقدم عرض لقنوات و مستقبلات الشبكات اللاسلكية فائقة الاتساع ومحاكات الاكثر استخداما منها و المتمثلة في IEEE 80215.3a و محاكات المستقبلات قليلة التعقيد في هذه القنوات. أما الباب الرابع فيقوم بعرض للقنوات الاكثر تعقيدا و المتمثلة في حقول الالغام ومحاكاتها ومحاكات المستقبلات قليلة التعقيد في هذه القنوات. و أخيرا الباب الخامس يقوم بتلخيص الرسالة و مناقشة اقتراحات لافكار مستقبلية متعلقة بالرسالة. وتختتم الرسالة بثبت للمراجع المستخدمة وملخص باللغة العربية.

ملخص باللغة العربية

1.1 مقدمة

أصبح الاتصال اللاسلكي قصير المدى جزءا أساسيا من الحياة اليومية بفضل النمو الهائل في نشر الشبكات اللاسلكية المحلية (WLAN) والشبكات اللاسلكية الشخصية (WPAN). وان ارتفاع معدل البيانات اللاسلكية الاتصال يعد واحدا من الدوافع الرئيسية للتطوير في مجال الاتصالات في العقد الماضي مثل خدمات الهاتف النقال اللاسلكية مثل الهواتف الخلوية و الراديو وأنظمة تحديد المواقع وغيرها من خدمات الاتصالات الشخصية (PCS) .المفهوم الأساسي للاتصالات فائقة الاتساع (UWB), هو لإرسال وتلقي اشارة راديو (RF) مدة قصيرة للغاية على نطاق واسع جدا من الترددات. وهذا هو على النقيض من الاتصالات علي الموجة التقليدية (أو "الضيقة"). وبالإضافة إلى ذلك فان الاتصالات فائقة الاتساع (UWB)، لها خصائص أخرى مفيدة مثل القدرة على تحمل إشارات من خلال العقبات والتنفيذ من خلال امكانات منخفضة التكلفة و التعقيد. هذه الخصائص، تعطي هذه التكنولوجيا القدرة على أن تستخدم في الاتصالات ذات السرعة العالية و القصيرة المدى مثل الشبكات اللاسلكية المحلية (WLAN). ومن الجدير بالذكر أن اتصالات الUWB يستخدم مجموعة واسعة من الحيز الترددي (3.1 حتي ،10.6 جيجاهيرتز) لنقل الحزم منخفضة الطاقة (41.3 dBm-)، فائقة القصر (0.2 – 1.5 ns) عن طريق الهواء. و هي أيضا قادرة على نقل البيانات في عدة مئات ميغابايت / ثانية، عادة في نطاقات قصيرة المدي (حتى 10 متر). ولذلك تعتبر هذه الأنظمة مناسبة لنقل البيانات للتطبيقات ذات المعدلات المرتفعة، ، وللاستخدام في أجهزة الاتصالات الاسلكية التي تعمل بالبطاريات.

1.2 الهدف من الرسالة

يتطرق البحث لموضوع الاتصالات اللاسلكية للانظمة فائقة الإتساع متعددة المستقبلات قليلة التعقيد و حساب إحتمال الخطا في الاشارات المستقبلة و ذلك في قنوات الاتصال الديناميكية. الرسالة تشمل دراسة إحتمال الخطأ في الاتصالات اللاسلكية للانظمة فائقة الإتساع متعددة المستقبلات قليلة التعقيد في قنوات متعددة و تصميم محاكاة لدراسة أفضل الحلول في هذه القنوات.

الأكاديمية العربية للعلوم والتكنولوجيا والنقل البحرى
كليـــــة الهندســـــة والتكنـــولـــوجيـــا
قسم هندسة الإلكترونيات والاتصالات

أداء الخطأ في المستقبلات منخفضة التعقيد لأنظمة الاتصالات اللاسلكية فائقة الاتساع في القنوات الديناميكية

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الماجستير

في

هندسة الإلكترونيات والاتصالات

إشراف

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قسم هندسة الحاسب
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الإســكندرية
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ERROR PERFORMANCE OF
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