行政院國家科學委員會專題研究計畫 成果報告

寬頻合作式無線多輸出入通訊系統--子計畫四：合作式多輸入輸出上行傳輸之干擾消除技術研究(2/2)

研究成果報告(完整版)

計畫類別：整合型
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執行期間：99年08月01日至100年10月31日
執行單位：國立交通大學電子工程學系及電子研究所

計畫主持人：馮智豪

計畫參與人員：此計畫無其他參與人員

報告附件：出席國際會議研究心得報告及發表論文

處理方式：本計畫可公開查詢

中華民國 100年10月25日

A Precoder / Two-Stage Interference Canceler for Block Based Single-Carrier Transmission with an Insufficient Guard Interval

Principal Investigator: *Carrson C. Fung*

Project Number: *NSC-99-2219-E-009-011*
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ABSTRACT

Herein proposed is a zero-inserting precoder and a two-stage linear equalizer, to shorten the guard interval in block-based single-carrier modulation. The first-stage equalizer consists of a linear single-tap-per-subcarrier *frequency*-domain equalizer (FDE). The second-stage equalizer maximizes the SINR, in the *time* domain, based on the interference-plus-noise estimated from the zero-padded subintervals of the single-carrier modulation. The proposed interference cancellation scheme is able to mitigate the IBI and ISI effect brought about by the reduction, or the elimination, of cyclic prefix, and in addition, can significantly reduce the effect of overlaid interference, multiple access interference and additive noise. Monte Carlo simulations demonstrate this scheme's efficacy in lowering the bit-error rate (BER) despite an insufficient guard interval.

***Index Terms*—** Equalizers, interference suppression, null subcarrier, OFDM

I. INTRODUCTION

Blocked based single-carrier (SC) transmission scheme has recently been proposed as an efficient transmission scheme for wireless communications. Its ability to offer the same advantages as OFDM without rendering high peak-to-average-power ratio (PAPR) has made it an attractive alternative to OFDM. Unfortunately, it too suffers from low spectrum efficiency due to the use of cyclic prefix (CP). Since OFDM and SC will coexist in 4G systems, such as IEEE 802.16m, LTE, and LTE-A, it is of utmost importance to look at issues related to reduced guard interval equalization since 1) it will enhance spectrum efficiency, 2) it will save valuable power at the terminal in the uplink, and 3) it will provide channel induced interference cancellation ability at the receiver.

A variety of algorithms have been proposed to deal with reduced guard interval SC based systems. [1]–[5] have proposed algorithms for reduced-CP based SISO-SC systems. [1] solves the problem of channel induced interference by using a simple loading scheme to eliminate ISI and IBI. However, it reduces the transmission rate. [2] proposed a block-by-block decision feedback equalization scheme which outperforms [1] in terms of BER, but at increased computational cost. A CP-free detection scheme was proposed in [3] which completely eliminates the use of the CP in order to minimize transmission overhead. A decision-directed equalization scheme was proposed by [5]. Although [5] requires less computational complexity than the turbo equalization scheme proposed in [4], it requires specially designed frame structure before it can be used. A reduced-CP based SIMO-SC FEQ has also been proposed by [6] which uses beamforming method to suppress ISI and IBI.

The proposed interference cancellation scheme is able to mitigate the IBI and ISI effect brought about by the reduction, or the elimination, of cyclic prefix, and in addition, can significantly reduce the effect of overlaid interference, multiple access interference and additive noise. Simulation results show that the proposed scheme can outperform traditional LMMSE-FDE by 5 dB at BER = 10^{-3} without incurring much increase in computational complexity. Section II describes the system model, followed by a detailed description of the proposed scheme in Section III. Complexity analysis and Monte Carlo simulation results are shown in Section IV and the report is concluded in Section V.

This work serves as a extension of our previous work done on uplink transmission using OFDM. Similar to this work, the proposed null subcarrier based interference cancellation technique was also able to overcame ISI and ICI incurred due to insufficient cyclic prefix, as well as overlaid system interference an co-channel interference. These techniques would enhance the throughput of the system by reducing the amount of overhead required for transmission.

II. SYSTEM MODEL

The information-bearing symbols $\{u(j), \forall j\}$ are segmented at the transmitter, into blocks of N symbols. Represent the k^{th} block as an N-element vector, $\mathbf{u}(k) = \left[u_{-\frac{N}{2}+1}(k), \cdots, u_0(k), \cdots, u_{\frac{N}{2}}(k)\right]^T$, where $u_n(k) = u\left(kN + \frac{N}{2} - 1 + n\right)$, for $n = -\frac{N}{2}+1, \ldots, \frac{N}{2}$.

Prefix $\mathbf{u}(k)$ with a length-G guard interval, which could be a cyclic prefix, i.e. a replication of the last v entries of $\mathbf{u}(k)$. Mathematically, this cyclic-prefixing operation equals the multiplication of $\mathbf{u}(k)$ into an $(N+G) \times N$ cyclic-prefix-insertion matrix $\mathbf{T}_{cp} = \begin{bmatrix} \mathbf{0}_{G\times(N-G)} & \mathbf{I}_G \\ \multicolumn{2}{c}{\mathbf{I}_N} \end{bmatrix}$, to produce the $(N+G)$-element vector, $\tilde{\mathbf{u}}(k) = \mathbf{T}_{cp}\mathbf{u}(k)$. This CP serves to reduce or to eliminate up to G taps of inter-block interference (IBI), caused by a frequency-selective fading channel. The guard interval needs not be a cyclic prefix as above, but could be entirely zero-energy symbols, or some mix of the two.

Consider a frequency-selective time-invariant channel of order Q, with the discrete-time impulse response taps of $h(0), h(1), \cdots, h(Q)$. This channel's output is modeled as corrupted by additive noise, symbolized by the $(N+G)$-element noise-vector $\boldsymbol{\eta}(k)$, which is zero-mean, is characterized by a priori known temporal correlation matrix of $\mathbf{R}_{\boldsymbol{\eta}(k)\boldsymbol{\eta}(k)}$, and is statistically independent from $\mathbf{u}(k)$.

Hence, the received data have the k^{th} symbol-block equal to

$$\tilde{\mathbf{r}}(k) = \mathbf{H}_0 \underbrace{\mathbf{T}_{cp}\mathbf{u}(k)}_{\tilde{\mathbf{u}}(k)} + \mathbf{H}_1 \underbrace{\mathbf{T}_{cp}\mathbf{u}(k-1)}_{\tilde{\mathbf{u}}(k-1)} + \boldsymbol{\eta}(k),$$

where $\mathbf{H}_0 \in \mathbb{C}^{(N+G)\times(N+G)}$ represents a lower triangular Toeplitz matrix, with its first column being $[h(0), h(1), \cdots, h(Q), 0, \cdots, 0]^T$; and $\mathbf{H}_1 \in \mathbb{C}^{(N+G)\times(N+G)}$ denotes an upper triangular Toeplitz matrix, with its first row as $[0, \cdots, 0, h(Q), \cdots, h(1)]$.

The receiver removes the cyclic prefix, via $\mathbf{R}_{cp} = [\mathbf{0}_{N\times G} \quad \mathbf{I}_{N\times N}]$, from the received signal to yield the N-element vector

$$\begin{aligned}
\mathbf{x}(k) &= \mathbf{R}_{cp} \underbrace{[\mathbf{H}_0\tilde{\mathbf{u}}(k) + \mathbf{H}_1\tilde{\mathbf{u}}(k-1) + \boldsymbol{\eta}(k)]}_{=\tilde{\mathbf{r}}(k)} \\
&= \mathbf{R}_{cp}\mathbf{H}_0\mathbf{T}_{cp}\mathbf{u}(k) + \underbrace{\mathbf{R}_{cp}\mathbf{H}_1\mathbf{T}_{cp}}_{=\mathbf{H}_{IBI}}\mathbf{u}(k-1) + \mathbf{R}_{cp}\boldsymbol{\eta}(k) \\
&= \underbrace{(\mathbf{R}_{CP}\mathbf{H}_0\mathbf{T}_{cp} + \mathbf{H}_{ISI})}_{=\mathbf{C}}\mathbf{u}(k) - \mathbf{H}_{ISI}\mathbf{u}(k) + \mathbf{H}_{IBI}\mathbf{u}(k-1) + \mathbf{R}_{cp}\boldsymbol{\eta}(k), \qquad (1)
\end{aligned}$$

with the $N\times N$ interblock interference (IBI) matrix $\mathbf{H}_{IBI} \triangleq \mathbf{R}_{cp}\mathbf{H}_1\mathbf{T}_{cp}$, the $N\times N$ intersymbol interference (ISI) matrix $\mathbf{H}_{ISI} = \mathbf{H}_{IBI}\mathbf{P}$, and the permutation matrix $\mathbf{P} = \begin{bmatrix} \mathbf{0}_{G\times(N-G)} & \mathbf{I}_G \\ \mathbf{I}_{N-G} & \mathbf{0}_{(N-G)\times G} \end{bmatrix}$. The $N\times N$ matrix $\mathbf{C} = \mathbf{W}_N^H\mathbf{D}\mathbf{W}_N$ in (1) is circulant, regardless of the relative magnitudes of G and Q. Moreover, the $N\times N$ matrix $\mathbf{D}$ signifies the channel transfer function matrix, which is diagonal for $G \geq Q$, with its $(k,k)^{th}$ entry equal to the k^{th} DFT coefficient of the channel impulse response $\{h(0), h(1), \cdots, h(Q)\}$ appended by $(N-Q-1)$ zeros, i.e. $[\mathbf{D}]_{k,k} = \sum_{q=0}^{Q} h(q)e^{-j\frac{2\pi}{N}kq}$, for $k = 0, \ldots, N-1$.

III. THE PROPOSED PRECODER-EQUALIZER SCHEME

A. The Proposed Zero-Inserting Precoder

To suppress the ISI and IBI, but with a length-G *in*sufficient cyclic prefix: [1] proposes inserting $2(Q-G)$ zero-energy symbols to correspond to the $Q-G$ non-zero columns in $\mathbf{H}_{IBI}$ plus the $Q-G$ non-zero columns in $\mathbf{H}_{ISI}$. The present scheme will *not* incur this $2(Q-G)$-symbol overhead, but deploys a guard interval (comprising of zero-energy symbols, plus an optional cyclic prefix) that may be *shorter* than the channel impulse response. From the data received during the zero-energy symbol intervals, the proposed scheme estimates the combined effects of the signal-of-interest's self-interference, of any multiple access user interference, of any overlaid interference, and of the additive noises. These denigrating effects are then subtracted from the information-bearing parts of the symbol block, via a SINR-maximizer in the receiver. This interference suppression approach philosophically resembles the null-subcarriers based methods in [7], [8] for OFDM, though the system architectures and the algorithmic details are very different. The present scheme can operate with any non-zero number of zero-energy symbols, with or without a cyclic prefix.

This zeros-inserting precoding can be realized by an $N \times (N-P)$ precoding matrix $\mathbf{T}_{zero}$, formed by inserting P number of all-zero rows into an $(N-P) \times (N-P)$ identity matrix. For example, appending all these zeros would require a precoding matrix of $\mathbf{T}_{zero} = \begin{bmatrix} \mathbf{I}_{(N-P)\times(N-P)} \\ \mathbf{0}_{P\times(N-P)} \end{bmatrix}$.

B. The Proposed Two-Stage Equalizer

At the receiver, (1) remains valid despite the zero-inserting precoder, but now has $\mathbf{u}(k) = \mathbf{T}_{zero}\mathbf{s}(k)$. The proposed linear equalizer involves a post-FFT linear single-tap-per-subcarrier *frequency*-domain equalizer (FDE) $\mathbf{W}$, followed by a post-IFFT signal-to-interference-and-noise (SINR) maximizer in the *time*-domain. These are shown in Figure 1.

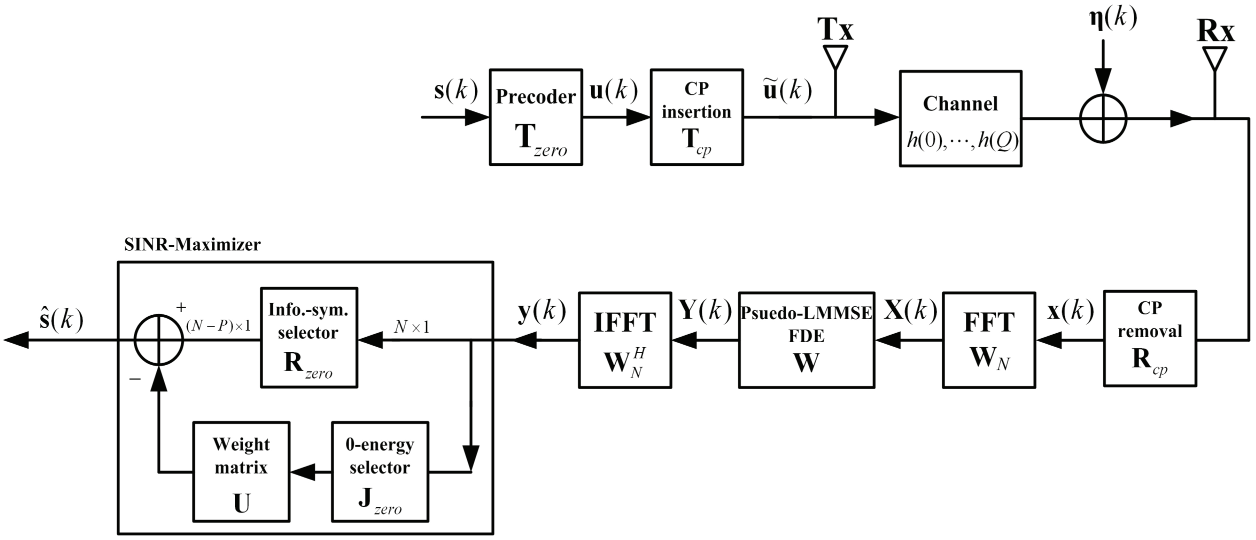

Fig. 1. The proposed zero-inserting precoder and the proposed two-stage equalizer.

The first stage is a single-tap-per-subcarrier frequency-domain linear equalizer (FDE),

$$\mathbf{W} \;=\; \mathbf{D}^H \left(\mathbf{D}\mathbf{D}^H + \frac{1}{\text{SNR}} \mathbf{I}_N \right)^{-1}, \tag{2}$$

where superscript ^{H} denotes complex-conjugate transposition, SNR $\triangleq \frac{\sigma_s^2}{\sigma_n^2}$, σ_s^2 refers to the signal power, and σ_n^2 symbolizes the noise power. The $N \times N$ diagonal $\mathbf{W}$ of (2) reduces the signal-of-interest's energy in the zero-energy symbol-intervals. (This $\mathbf{W}$ would constitute a linear minimum-mean-square-error (LMMSE) equalizer, if no interference existed and if $G \geq Q$.) The output of $\mathbf{W}$ equals

$$\mathbf{y}(k) \;=\; \mathbf{W}_N^H \mathbf{W} \mathbf{W}_N \underbrace{\left\{ \mathbf{C}\mathbf{u}(k) - \mathbf{H}_{ISI}\mathbf{u}(k) + \mathbf{H}_{IBI}\mathbf{u}(k-1) + \mathbf{n}(k) \right\}}_{=\mathbf{x}(k)}. \tag{3}$$

For the second stage:

(a) Form a $P \times N$ "zero-*selection*" matrix, to block all information-bearing symbol-intervals (which have non-zero energy at transmission). That is, $\mathbf{J}_{zero} = \left[\mathbf{0}_{P\times(N-P)} \middle| \mathbf{I}_{P\times P} \right]$ would be compatible with the earlier defined $\mathbf{T}_{zero}$.

(b) Also form a $(N-P) \times N$ "zero-*removal*" matrix, to remove the precoder-inserted zeros. That is, $\mathbf{R}_{zero} = \left[\mathbf{I}_{(N-P)\times(N-P)} \middle| \mathbf{0}_{(N-P)\times P} \right]$ would be compatible with the earlier defined $\mathbf{T}_{zero}$ and $\mathbf{J}_{zero}$.

Next, form the $(N-P) \times P$ matrix $\mathbf{U}$, to minimize the mean-squared error ξ between the signal-output from $\mathbf{R}_{zero}$ and $\mathbf{J}_{zero}$, i.e.

$$\xi_{\min} \;=\; \min_{\mathbf{U}} \underbrace{E\left[\|\mathbf{i}(k) - \mathbf{U}\mathbf{J}_{zero}\mathbf{y}(k)\|_2^2 \right]}_{\triangleq \xi}, \tag{4}$$

where $\mathbf{i}(k) \triangleq \mathbf{R}_{zero}\mathbf{W}_N^H \mathbf{W}\mathbf{W}_N \left[-\mathbf{H}_{ISI}\mathbf{u}(k) + \mathbf{H}_{IBI}\mathbf{u}(k-1) + \mathbf{n}(k) \right]$ represents the interference and noises in the information-bearing symbols' durations. The optimization in (4) can be solved via the principle of orthogonality, i.e. $E[\mathbf{U}\mathbf{J}_{zero}\mathbf{y}(k) \; (\mathbf{i}(k) - \mathbf{U}\mathbf{J}_{zero}\mathbf{y}(k))^H] = \mathbf{0}$, to yield $\mathbf{U} = \mathbf{R}_{zero}\mathbf{R}_{\mathbf{i}(k)\mathbf{i}(k)}\mathbf{J}_{zero}^H \left[\mathbf{J}_{zero}\mathbf{R}_{\mathbf{y}(k)\mathbf{y}(k)}\mathbf{J}_{zero}^H \right]^{-1}$, which may be pre-calculated offline, using the prior knowledge that

$$\begin{aligned} \mathbf{R}_{\mathbf{i}(k)\mathbf{i}(k)} \;\triangleq\; & \mathbf{W}_N^H \mathbf{W}\mathbf{W}_N \left\{ \mathbf{H}_{ISI}\mathbf{R}_{\mathbf{u}(k)\mathbf{u}(k)} (\mathbf{W}_N^H \mathbf{W}\mathbf{W}_N \mathbf{H}_{ISI})^H \right. \\ & \left. + \mathbf{H}_{IBI}\mathbf{R}_{\mathbf{u}(k-1)\mathbf{u}(k-1)} (\mathbf{W}_N^H \mathbf{W}\mathbf{W}_N \mathbf{H}_{IBI})^H + \mathbf{R}_{\mathbf{n}(k)\mathbf{n}(k)} (\mathbf{W}_N^H \mathbf{W}\mathbf{W}_N)^H \right\}. \end{aligned} \tag{5}$$

Lastly, the $(N-P) \times 1$ transmitted symbol-vector $\mathbf{s}(k)$ is estimated by the receiver as $\hat{\mathbf{s}}(k) = (\mathbf{R}_{zero} - \mathbf{U}\mathbf{J}_{zero})\, \mathbf{y}(k)$.

The real-time computational complexity of this proposed precoder/equalizer scheme is compared in Table I against the customary LMMSE-FDE (i.e. (2) alone, without the precoder and without the

SINR-maximizer) in terms of N and P. As $\mathbf{W}$ and $\mathbf{U}$ may be precomputed offline, while $\mathbf{T}_{zero}$, $\mathbf{R}_{zero}$ and $\mathbf{J}_{zero}$ involve no multiplication nor addition – these do not contribute to the real-time computational load.

TABLE I

COMPUTATIONAL COMPLEXITY OF PROPOSED SCHEME AND CUSTOMARY LMMSE-FDE.

	LMMSE-Based FDE	The Proposed 2-Stage Equalizer
# of complex-value multiplications	$N\log_2 N + N$	$N\log_2 N + N + (N-P)P$
# of complex-value additions	$2N\log_2 N$	$2N\log_2 N + (N-P)P$

IV. MONTE CARLO SIMULATIONS

The information-bearing symbols $\{s(k)\}$ are modulated with equiprobable QPSK-symbols. The transmitted signal has $N = 64$. The channel impulse response has $Q + 1 = 11$ complex-valued taps, each randomly generated and not cross-correlated among themselves. Each tap's real-value part and imaginary-value part are not cross-correlated. Each tap is Gaussian, zero-mean. The q^{th} tap has an exponentially decaying variance of $\sigma_q^2 = \left(1 - e^{-\frac{T_s}{T_{RMS}}}\right) e^{-q\frac{T_s}{T_{RMS}}}, \forall q = 0, \cdots, Q$, where T_s denotes the sampling period, and T_{RMS} symbolizes the root-mean-square delay-spread of the channel. The additive noise is complex-value, temporally uncorrelated, zero-mean, Gaussian, with a noise power of $\sigma^2_{\boldsymbol{\eta}(k)\boldsymbol{\eta}(k)}$.

Consider these two curves in Figure 2:

(i) The top dashed black curve at $G = 6$ and $P = 0$ (i.e. an insufficient CP but no zeros-inserting precoding).

(ii) The bottom green curve at $G = 0$ and $P = 6$ (i.e. no CP but 6 zeros-inserted by the precoder, as proposed in this report).

These two curves both incur the same overhead of $P + G = 6$ symbols, but the proposed scheme lowers the BER by $1 - \frac{9\times10^{-4}}{3.8\times10^{-3}} = 76\%$ at SNR= 15dB, and by $1 - \frac{3.2\times10^{-5}}{1.4\times10^{-3}} = 98\%$ at SNR= 25dB. In terms of the computational complexity for case (ii) above, Table I suggests that the proposed scheme would increase the popular LMMSE-FDE method's number of complex-value multiplications by 60% and the number of complex-value additions by 45%.

Alternatively, if the transmission overhead is lightened to just 4 inserted zeros (i.e. $\frac{(6+64)-(4+64)}{6+64} = 2.9\%$ reduction overhead on the data-rate) but no cyclic prefix, then the proposed scheme can still lower the BER by $1 - \frac{2.9\times10^{-3}}{3.8\times10^{-3}} = 24\%$ at SNR= 15dB, and by $1 - \frac{7.8\times10^{-4}}{1.4\times10^{-3}} = 44\%$ at SNR= 25dB.

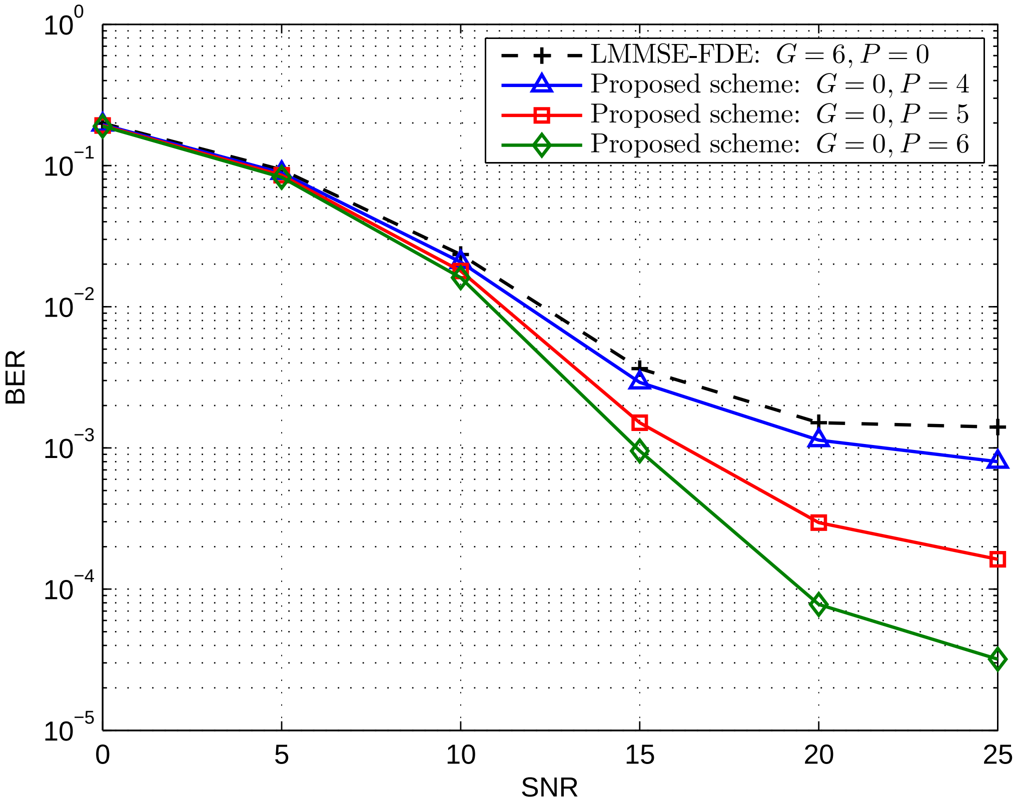

Fig. 2. The BER of the proposed scheme 's BER performance of the proposed algorithm Ib with P zero-energy symbols inserted at the end of symbol-block v.s. LMMSE-FDE with length of $G = 6$ CP inserted where $P \leq G$. The channel has an exponential decay with $\frac{T_s}{T_{rms}} = \frac{1}{4}$.

V. CONCLUSION

For cyclic-prefixed block-based single-carrier-based communication systems, this proposes a zero-inserting time-domain precoder and an accompanying two-stage equalizer, to allow an insufficient guard interval, in order to reduce the transmission overhead. This proposed precoder is predefined offline and requires no iteration, no feed-forward, and no decision feedback.

This work is extremely crucial for uplink transmission in next generation 4G wireless systems as block based single-carrier modulation is slated to be used extensively.

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國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：___年___月___日

計畫編號	NSC NSC-99-2219-E-009-011		
計畫名稱	Interference Cancellation Techniques for Cooperative MIMO Uplink Transmission		
出國人員姓名	Carrson C. Fung	服務機構及職稱	Dept. of Electronics Engineering, NCTU, Assistant Professor
會議時間	Aug. 29~Sep. 2, 2011	會議地點	Barcelona, Spain
會議名稱	(中文) 第十九屆歐洲訊號處理會議 (英文) 19th European Signal Processing Conference		
發表論文題目	(中文) 在多天線分頻多工架構之下空間多工系統中最佳位元錯誤率之單模前置編碼設計 (英文) BER Optimized Unimode Precoder Design for MIMO-OFDM Based Spatial Multiplexing Systems		

一、參加會議經過

Conference: 19th European Signal Processing Conference
Date: Aug. 29-Sep. 2, 2011

二、與會心得

The 2011 European Signal Processing conference is the flagship conference of European Signal Processing Society, EURASIP. It took place at Barcelona, Spain from Aug. 29 – Sep. 2, 2011. The conference has a total of 8 tutorials, held in 2 different sessions. I was able to attend 2 tutorials, which are "Semidefinite relaxation of nonconvex quadratic optimization: a key technique in signal processing and communications", and "Applications of large random matrices to digital communications and statistical signal processing". The first one gave an overview on semidefinite relaxation technique and its use to solve many useful digital communication problems, including MIMO beamforming and MIMO decoding. The second one gave an overview of large random matrices theory and its usage in obtaining theoretical bounds for different digital communication problems, which are otherwise difficult to obtain in finite size matrix case. I also attended numerous talks on MIMO beamforming, spectrum sharing for MIMO interference relay channels, training sequence design for multiuser MIMO-OFDM systems, and interference alignment. All of these presentations are highly related to my current research topics in signal processing and communications. I also attended three plenary presentations given by Prof. Sergio Verdu on “What is Information Theory?", Prof. Sergios Theordoridis on “Adaptive Learning in a World of Projections”, and Prof. Helmut Bolcskei on “Uncertainty Relations and Signal Recovery”. The first one gave an overview on information theory, its impact in diverse areas in signal processing, and what the future direction in IT should be. The second one discussed the deficiencies of today’s parameter estimation technique and proposed a novel approach based on projections on intersection of sets to the problem that would eliminate such deficiencies. The third one showed how uncertainty relations allow to build a unified framework for understanding the fundamental limits of a wide range of signal reconstruction problems.

三、考察參觀活動(無是項活動者略)

The 2011 European Signal Processing Conference is the flagship conference of EURASIP. The conference focuses on key aspects related to signal processing. Exploration of new avenues and methodologies of communications are also encouraged. Areas of interests include selected areas in communications (such as cognitive radio, cooperative communications, smart grid communications), communication theory, signal processing for communications, wireless communications, wireless and mobile networking, adhoc, sensor and mesh networking, signal recovery, detection and estimation, and audio and electroacoustics. There were numerous plenary talks, tutorial sessions and technical sessions (35 in total). Finally, I was able to present my paper during the Signal Processing for Communications session. The proceedings of the conference were provided, as well as the conference schedule, which eased navigation at the conference venue.

四、建議

I strongly recommend my own students to attend this conference as it contains many papers relevant to their research. Since this is the flagship conference of EURASIP, not only will the students benefit from the technical content, but they will also be able to meet many people who are working in similar research areas. I have found enhancements in my own research through active discussions with many of these experts during and after the conference. This conference also serves to give students more of a global view of what is going around besides the research topics they are working on. This will be extremely useful to Ph.D. students, who will possibly be faculty themselves upon graduation, in order to assist them in selecting which research topics others are working on and problems that remain to be solved. Besides, the tutorials are free of charge and it serves to encourage more people to attend.

五、攜回資料名稱及內容

Proceedings CD, bag

六、其他

Next year’s EUSIPCO will take place in Bucharest, Romania.

國科會補助計畫衍生研發成果推廣資料表

日期:2011/10/25

國科會補助計畫	計畫名稱: 子計畫四：合作式多輸入輸出上行傳輸之干擾消除技術研究(2/2)
	計畫主持人: 馮智豪
	計畫編號: 99-2219-E-009-011- 學門領域: 接取技術(網通國家型)

無研發成果推廣資料

99 年度專題研究計畫研究成果彙整表

計畫主持人：馮智豪　**計畫編號：**99-2219-E-009-011-

計畫名稱：寬頻合作式無線多輸出入通訊系統--子計畫四：合作式多輸入輸出上行傳輸之干擾消除技術研究(2/2)

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	1	1	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	1	1	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	3	3	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	No

🟥	**成果項目**	**量化**	**名稱或內容性質簡述**
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標
□未達成目標（請說明，以 100 字為限）
　□實驗失敗
　□因故實驗中斷
　□其他原因
說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：■已發表 □未發表之文稿 □撰寫中 □無
專利：□已獲得 □申請中 ■無
技轉：□已技轉 □洽談中 ■無
其他：（以 100 字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

Herein proposed is a zero-inserting precoder and a two-stage linear equalizer, to shorten the guard interval in block-based single-carrier modulation. The first-stage equalizer consists of a linear single-tap-per-subcarrier frequency-domain equalizer (FDE). The second-stage equalizer maximizes the SINR, in the time domain, based on the interference-plus-noise estimated from the zero-padded subintervals of the single-carrier modulation. The proposed interference cancellation scheme is able to mitigate the IBI and ISI effect brought about by the reduction, or the elimination, of cyclic prefix, and in addition, can significantly reduce the effect of overlaid interference, multiple access interference and additive noise. The reduction of cyclic prefix also enhances the throughput of the system.