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Assessing Receiver Performance in Interference-Aware Environments with Channel Estimation Error Considerations

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Abstract

We consider the backdrop of uncorrelated Rayleigh flat fading channels and introduce a model that characterizes estimation errors as independent complex Gaussian random variables. By delving into this context, we derive an upper bound on the pairwise error probability (PEP). Most intriguingly, our analysis reveals that the interference-aware receiver maintains full diversity even in the presence of channel estimation errors, further accentuating its robustness. To provide a holistic comparison, we contrast the performance of the interference-aware receiver with that of the MMSE (Minimum Mean Squared Error) receiver. Our findings underscore a notable disparity: the degradation in the performance of the MMSE receiver significantly surpasses that of the interference-aware receiver in scenarios involving imperfect CSI..

Introduction

To tackle the surging demands for elevated spectral efficiency, contemporary cellular communication systems are embracing aggressive frequency reuse factors as seen in LTE, LTE-Advanced, and WiMax (IEEE 802.16m). Departing from conventional strategies that restrict spectrum reusability and consequently limit degrees of freedom, modern systems are instead adopting exhaustive spatial spectrum reuse [1]. This paradigm shift has led to interference-limited scenarios, where interferences assume prominence in constraining the performance of cell edge users. To address this, various transmission and reception techniques have been introduced, including interference alignment [2] and coordinated multi-point transmission (CoMP) [3] at the transmitter end, and linear minimum mean square error (MMSE) and zero forcing solutions [4] at the receiver end. Notably, advanced interference-aware receivers [5] have proven to be effective in mitigating interference in cellular systems. However, the efficacy of these mitigation techniques hinges on the availability of accurate channel state information (CSI), a concern heightened by practical limitations. This concern is particularly relevant for interfering signals, whose control information and pilot signals may not always be available. Even for desired signals, channel estimates are imperfect due to noise, wireless channel dynamics, and finite pilot symbols [6]. Consequently, the analysis based on perfect CSI serves only as an upper bound, necessitating the exploration of algorithmic performance in the presence of channel estimation errors.

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This paper delves into the performance of diverse receiver algorithms in the context of imperfect CSI. These receivers initially estimate channels using pilot symbols and subsequently employ these estimated channels in a manner consistent with ideal CSI scenarios. These receivers are termed "mismatched receivers" and have garnered attention for their role in managing estimation errors. Our study particularly focuses on the performance of interference-aware receivers in the presence of channel estimation errors within uncorrelated Rayleigh flat fading channels . We model the estimation error as independent complex Gaussian random variables and derive an upper bound on the coded pairwise error probability (PEP). Importantly, we establish that the interference-aware receiver maintains full diversity even in the presence of channel estimation errors. Our analysis leverages the moment generating function (MGF) to characterize the behavior of a complex quadratic form. In summary, this research advances our understanding of interference-aware receiver performance in scenarios marked by channel estimation errors. By providing insights into the receiver's behavior under practical constraints, this study contributes to the optimization and real-world application of interference mitigation techniques within evolving cellular communication systems.

System model

$$\mathbf{y}_k = \mathbf{h}_{1,k} x_{1,k} + \mathbf{h}_{2,k} x_{2,k} + \mathbf{z}_k = \mathbf{H}_k \mathbf{x}_k + \mathbf{z}_k, \quad k = 1, \cdots, T \tag{1}$$

$$\mathbf{y}_{p,k} = \mathbf{h}_{1,k} x_{p,k} + \mathbf{z}_{1,k} \tag{2}$$

$$\hat{\mathbf{h}}_{1,k} = \frac{1}{\sigma_p} \mathbf{y}_{p,k} x_{p,k}^* = \mathbf{h}_{1,k} + \tilde{\mathbf{h}}_{1,k} \tag{3}$$

INTERFERENCE-AWARE RECEIVER

$$\Lambda_1^i \left(\mathbf{y}_k, c_{k'} \right) \approx \min_{x_1 \in \chi^i_{1,c_{k'}}, x_2 \in \chi_2} \frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{h}}_{1,k} x_1 - \hat{\mathbf{h}}_{2,k} x_2 \right\|^2 \tag{4}$$

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$$\Lambda_1^i(\mathbf{y}_k, c_{k'}) \approx \min_{x_1 \in \chi^i_{1,c_{k'}}, x_2 \in \chi_2} \frac{1}{N_0} \Big\{ \|\mathbf{y}_k\|^2 + \left\|\hat{\mathbf{h}}_{1,k} x_1\right\|^2 + \left\|\hat{\mathbf{h}}_{2,k} x_2\right\|^2 - \left\|\hat{\mathbf{h}}_{1,k}\right\| (2y_{1,k}x_1^*)_R + 2\left\|\hat{\mathbf{h}}_{2,k}\right\| (2\rho_{12,k}x_1^* x_2)_R - \left\|\hat{\mathbf{h}}_{2,k}\right\| (2y_{2,k}x_2^*)_R \Big\} \quad (5)$$

$$\Lambda_1^i(\mathbf{y}_k, c_{k'}) \approx \min_{x_1 \in \chi^i_{1,c_{k'}}, x_2 \in \chi_2} \frac{1}{N_0} \Big\{ \left\|\hat{\mathbf{h}}_{1,k} x_1\right\|^2 - \left\|\hat{\mathbf{h}}_{1,k}\right\| (2y_{1,k}x_1^*)_R + 2\left\|\hat{\mathbf{h}}_{2,k}\right\| x_{2,R} \left(\rho_{12,k,R}x_{1,R} + \rho_{12,k,I}x_{1,I} - y_{2,k,R}\right) + \left\|\hat{\mathbf{h}}_{2,k}\right\|^2 x_{2,R}^2 + 2\left\|\hat{\mathbf{h}}_{2,k}\right\| x_{2,I} \left(\rho_{12,k,R}x_{1,I} - \rho_{12,k,I}x_{1,R} - y_{2,k,I}\right) + \left\|\hat{\mathbf{h}}_{2,k}\right\|^2 x_{2,I}^2 \Big\} \quad (6)$$

$$x_{2,R} \rightarrow -\frac{\rho_{12,k,R}x_{1,R} + \rho_{12,k,I}x_{1,I} - y_{2,k,R}}{\left\|\hat{\mathbf{h}}_{2,k}\right\|}$$
$$x_{2,I} \rightarrow -\frac{\rho_{12,k,R}x_{1,I} - \rho_{12,k,I}x_{1,R} - y_{2,k,I}}{\left\|\hat{\mathbf{h}}_{2,k}\right\|} \quad (7)$$

$$\mathsf{LLR}_1^i = \Lambda_1^i(\mathbf{y}_k, c_{k'} = 1) - \Lambda_1^i(\mathbf{y}_k, c_{k'} = 0) \quad (8)$$

PAIRWISE ERROR PROBABILITY (PEP) ANALYSIS

$$\mathcal{P}^{\hat{\mathbf{c}}_1}_{\mathbf{c}_1|\hat{\mathbf{H}}} = P\left(\sum_{k'} \min_{x_1 \in \chi^i_{1,c_{k'}}, x_2 \in \chi_2} \frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{h}}_{1,k} x_1 - \hat{\mathbf{h}}_{2,k} x_2 \right\|^2 \geq \sum_{k'} \min_{x_1 \in \chi^i_{1,\hat{c}_{k'}}, x_2 \in \chi_2} \frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{h}}_{1,k} x_1 - \hat{\mathbf{h}}_{2,k} x_2 \right\|^2 \middle| \hat{\mathbf{H}} \right) \quad (9)$$

where $\hat{\mathbf{H}} = \left[\hat{\mathbf{h}}_1 \ \hat{\mathbf{h}}_2\right]$, i.e., the estimated channel for the complete codeword. We consider the worst case scenario when the Hamming distance between the two codeword is d_{free}. In that case, all the terms on the two sides of inequality in (9) will be same except for d_{free} points where $\hat{c}_{k'} = \bar{c}_{k'}$. Note that $\bar{(.)}$ denotes the binary complement. Let's denote

$$\tilde{x}_{1,k}, \tilde{x}_{2,k} = \arg \min_{x_1 \in \chi^i_{1,c_{k'}}, x_2 \in \chi_2} \frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{h}}_{1,k} x_1 - \hat{\mathbf{h}}_{2,k} x_2 \right\|^2$$

$$\hat{x}_{1,k}, \hat{x}_{2,k} = \arg \min_{x_1 \in \chi^i_{1,\bar{c}_{k'}}, x_2 \in \chi_2} \frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{h}}_{1,k} x_1 - \hat{\mathbf{h}}_{2,k} x_2 \right\|^2$$

As $x_{1,k}$ and $x_{2,k}$ are the transmitted symbols, it leads to

$$\frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{h}}_{1,k} x_{1,k} - \hat{\mathbf{h}}_{2,k} x_{2,k} \right\|^2 \geq \frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{h}}_{1,k} \tilde{x}_{1,k} - \hat{\mathbf{h}}_{2,k} \tilde{x}_{2,k} \right\|^2$$

The PEP is therefore upperbounded as

$$\mathcal{P}^{\hat{\mathbf{c}}_1}_{\mathbf{c}_1|\hat{\mathbf{H}}} \leq P\left(\sum_{k,d_{free}} \frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{h}}_{1,k} x_{1,k} - \hat{\mathbf{h}}_{2,k} x_{2,k} \right\|^2 \geq \sum_{k,d_{free}} \frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{h}}_{1,k} \hat{x}_{1,k} - \hat{\mathbf{h}}_{2,k} \hat{x}_{2,k} \right\|^2 \middle| \hat{\mathbf{H}} \right) \quad (10)$$

For the brevity of notations, we concatenate the two channels as $\mathbf{H}_k = [\mathbf{h}_{1,k} \ \mathbf{h}_{2,k}]$. So the estimated channel is given as $\hat{\mathbf{H}}_k = \mathbf{H}_k + \tilde{\mathbf{H}}_k$, where $\tilde{\mathbf{H}}_k$ represents the concatenated channel estimation error being distributed as $\mathcal{CN}(\mathbf{0}, N_0\mathbf{I})$ while $\hat{\mathbf{H}}_k$ is distributed as $\mathcal{CN}(\mathbf{0}, (1+N_0)\mathbf{I})$. Developing it further

$$\mathcal{P}^{\hat{\mathbf{c}}_1}_{\mathbf{c}_1|\hat{\mathbf{H}}} \leq P\left(\sum_{k,d_{free}} \frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{H}}_k \mathbf{x}_k \right\|^2 \geq \sum_{k,d_{free}} \frac{1}{N_0} \left\| \mathbf{y}_k - \hat{\mathbf{H}}_k \hat{\mathbf{x}}_k \right\|^2 \middle| \hat{\mathbf{H}} \right)$$
$$= P\left(\sum_{k,d_{free}} \frac{1}{N_0} \left\{ -2\Re\left(\mathbf{z}^\dagger \left(\hat{\mathbf{H}}_k (\mathbf{x}_k - \hat{\mathbf{x}}_k)\right)\right)\right\} \geq \sum_{k,d_{free}} \frac{1}{N_0} \left\{ \left\| \hat{\mathbf{H}}_k \hat{\mathbf{x}}_k \right\|^2 - \left\| \hat{\mathbf{H}}_k \mathbf{x}_k \right\|^2 + 2\Re\left(\mathbf{H}\mathbf{x}_k\right)^\dagger \left(\hat{\mathbf{H}} (\mathbf{x}_k - \hat{\mathbf{x}}_k)\right) \right\} \middle| \hat{\mathbf{H}} \right) \quad (11)$$

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Replacing $\mathbf{H}_k$ by $\hat{\mathbf{H}}_k - \tilde{\mathbf{H}}_k$, we get

$$\begin{aligned}
\mathcal{P}^{\hat{\mathbf{c}}_1}_{\mathbf{c}_1|\hat{\mathbf{H}}} \le P \Bigg(& \sum_{k,d_{free}} \frac{1}{N_0} \left\{ -2\Re\left(\mathbf{z}^\dagger \left(\hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right) \right) \right\} \ge \\
& \sum_{k,d_{free}} \frac{1}{N_0} \Big\{ \left\| \hat{\mathbf{H}}_k \hat{\mathbf{x}}_k \right\|^2 + \left\| \hat{\mathbf{H}}_k \mathbf{x}_k \right\|^2 - 2\Re\left(\hat{\mathbf{H}}_k \mathbf{x}_k \right)^\dagger \left(\hat{\mathbf{H}} \hat{\mathbf{x}}_k \right) \\
& + 2\Re\left(\tilde{\mathbf{H}}_k \mathbf{x}_k \right)^\dagger \left(\hat{\mathbf{H}} \hat{\mathbf{x}}_k \right) - 2\Re\left(\tilde{\mathbf{H}}_k \mathbf{x}_k \right)^\dagger \left(\hat{\mathbf{H}} \mathbf{x}_k \right) \Big\} \Big| \hat{\mathbf{H}} \Bigg) \\
= P \Bigg(& \sum_{k,d_{free}} \frac{1}{N_0} \left\{ -2\Re\left(\mathbf{z}^\dagger \left(\hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right) \right) \right\} \ge \\
& \sum_{k,d_{free}} \frac{1}{N_0} \left\{ \left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2 - 2\Re\left(\tilde{\mathbf{H}}_k \mathbf{x}_k \right)^\dagger \left(\hat{\mathbf{H}} \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right) \right\} \Big| \hat{\mathbf{H}} \Bigg) \\
= P \Bigg(& \sum_{k,d_{free}} \frac{1}{N_0} \left\{ -2\Re\left(\mathbf{z}^\dagger \left(\hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right) \right) + 2\Re\left(\tilde{\mathbf{H}}_k \mathbf{x}_k \right)^\dagger \left(\hat{\mathbf{H}} \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right) \right\} \ge \\
& \sum_{k,d_{free}} \frac{1}{N_0} \left\{ \left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2 \right\} \Big| \hat{\mathbf{H}} \Bigg)
\end{aligned} \tag{12}$$

$\sum_{k,d_{free}} \frac{1}{N_0} \left\{ -2\Re\left(\mathbf{z}^\dagger \left(\hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right) \right) + 2\Re\left(\tilde{\mathbf{H}}_k \mathbf{x}_k \right)^\dagger \left(\hat{\mathbf{H}} \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right) \right\}$ is a Gaussian random variable with zero mean and variance given by

$$\sum_{k,d_{free}} \frac{2}{N_0} \left[\left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2 + \left\| \mathbf{x}_k^\dagger \right\|^2 \left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2 \right]$$

Using the Gaussian Q function, we develop (12) as

$$\begin{aligned}
\mathcal{P}^{\hat{\mathbf{c}}_1}_{\mathbf{c}_1|\hat{\mathbf{H}}} &\le Q \left(\frac{\sum_{k,d_{free}} \frac{1}{N_0} \left\{ \left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2 \right\}}{\sqrt{\sum_{k,d_{free}} \frac{2}{N_0} \left(\left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2 + \left\| \mathbf{x}_k^\dagger \right\|^2 \left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2 \right)}} \right) \\
&= Q \left(\frac{\sum_{k,d_{free}} \frac{1}{N_0} \left\{ \left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2 \right\}}{\sqrt{\sum_{k,d_{free}} \frac{2}{N_0} \left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2 \left(1 + \left\| \mathbf{x}_k^\dagger \right\|^2 \right)}} \right) \\
&= Q \left(\sqrt{\sum_{k,d_{free}} \frac{1}{2N_0} \left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2} \left(1 + \left\| \mathbf{x}_k^\dagger \right\|^2 \right)^{-1/2} \right) \\
&\le Q \left(\sqrt{\sum_{k,d_{free}} \frac{1}{2N_0} \left\| \hat{\mathbf{H}}_k \left(\mathbf{x}_k - \hat{\mathbf{x}}_k \right) \right\|^2} \right) \\
&= Q \left(\sqrt{\frac{1}{2N_0} \mathrm{vec}\left(\hat{\mathbf{H}}^\dagger \right)^\dagger \boldsymbol{\Delta} \mathrm{vec}\left(\hat{\mathbf{H}}^\dagger \right)} \right)
\end{aligned}$$

where $\boldsymbol{\Delta} = \mathbf{I}_{n_r} \otimes \mathbf{D}\mathbf{D}^\dagger$ while $\mathbf{D}_{2K \times K} = \mathrm{diag}\left\{ \mathbf{x}_1 - \hat{\mathbf{x}}_1, \mathbf{x}_2 - \hat{\mathbf{x}}_2, \cdots, \mathbf{x}_{k,d_{free}} - \hat{\mathbf{x}}_{k,d_{free}} \right\}$ and $K = d_{free}$. Note that $\hat{\mathbf{H}} = \left[\hat{\mathbf{H}}_1 \cdots \hat{\mathbf{H}}_K \right]$. $\mathbf{D}\mathbf{D}^\dagger$ is a $2K \times 2K$ block diagonal matrix with real entries on the main diagonal and its eigenvalues are

$$\lambda_k \left(\mathbf{D}\mathbf{D}^\dagger \right) = \begin{cases} \left\| \mathbf{x}_k - \hat{\mathbf{x}}_k \right\|^2 & \text{for} \quad k = 1, \cdots, d_{free} \\ 0 & \text{for} \quad k = d_{free} + 1, \cdots, 2d_{free} \end{cases}$$

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Using the Chernoff bound $Q(x) \leq \frac{1}{2}\exp\left(\frac{-x^2}{2}\right)$ [19], the conditional PEP can be written as

$$\mathcal{P}^{\hat{\mathbf{c}}_1}_{\mathbf{c}_1|\hat{\mathbf{H}}} \leq \frac{1}{2}\exp\left(-\frac{1}{4N_0}\mathrm{vec}\left(\hat{\mathbf{H}}^\dagger\right)^\dagger \boldsymbol{\Delta}\mathrm{vec}\left(\hat{\mathbf{H}}^\dagger\right)\right) \quad (13)$$

The moment generating function of a Hermitian quadratic form in complex Gaussian random variable $\mathbf{m}^\dagger\mathbf{A}\mathbf{m}$ where column vector $\mathbf{m}$ is a circularly symmetric complex Gaussian vector i.e. $\mathbf{m} \sim \mathcal{NC}\left(\boldsymbol{\mu}, \sum\right)$ where the mean $\boldsymbol{\mu} = E[\mathbf{m}]$ and the covariance matrix $\sum = E\left[\mathbf{m}\mathbf{m}^\dagger\right] - \boldsymbol{\mu}\boldsymbol{\mu}^\dagger$, and a Hermitian matrix $\mathbf{A}$, is given by

$$E\left[\exp\left(-t\mathbf{m}^\dagger\mathbf{A}\mathbf{m}\right)\right] = \frac{\exp\left[-t\boldsymbol{\mu}^\dagger\mathbf{A}\left(\mathbf{I}+t\sum\mathbf{A}\right)^{-1}\boldsymbol{\mu}\right]}{\det\left(\mathbf{I}+t\sum\mathbf{A}\right)} \quad (14)$$

As the argument of exponential in (13) is the Hermitian quadratic form of a Gaussian random variable so we get

$$\begin{aligned}\mathcal{P}^{\hat{\mathbf{c}}_1}_{\mathbf{c}_1} &\leq \frac{1}{2\det\left(\mathbf{I}+\frac{(1+N_0)}{4N_0}\mathbf{I}\boldsymbol{\Delta}\right)} \\ &= \frac{1}{2\prod_{k=1}^{d_{free}}\left(1+\frac{(1+N_0)}{4N_0}\|\mathbf{x}_k-\hat{\mathbf{x}}_k\|^2\right)^{n_r}} \\ &\leq \frac{1}{2}\prod_{k=1}^{d_{free}}\left(\frac{4N_0}{(1+N_0)\left(\|\mathbf{x}_k-\hat{\mathbf{x}}_k\|^2\right)}\right)^{n_r} \quad (15)\end{aligned}$$

Note that $\|\mathbf{x}_k-\hat{\mathbf{x}}_k\|^2 \geq d^2_{1,\min}+d^2_{2,\min}$ if $\hat{x}_{2,k} \neq x_{2,k}$ and $\|\mathbf{x}_k-\hat{\mathbf{x}}_k\|^2 \geq d^2_{1,\min}$ if $\hat{x}_{2,k} = x_{2,k}$. Let $P\left(\hat{x}_{2,k} \neq x_{2,k}\right)$ is the uncoded probability that the output of max log MAP demodulator $\hat{x}_{2,k}$ is not equal to the actual transmitted symbol $x_{2,k}$. The PEP is upperbounded as

$$\mathcal{P}^{\hat{\mathbf{c}}_1}_{\mathbf{c}_1} \leq \frac{1}{2}\left(\frac{4N_0}{\sigma_1^2\breve{d}^2_{1,\min}}\right)^{n_r d_{free}}\left(\frac{1}{1+N_0}\right)^{n_r d_{free}}$$
$$\left(\sum_{j=0}^{d_{free}} \mathrm{C}_j^{d_{free}}\frac{\left(P\left(\hat{x}_{2,k}\neq x_{2,k}\right)\right)^j\left(1-P\left(\hat{x}_{2,k}\neq x_{2,k}\right)\right)^{d_{free}-j}}{\left(1+\frac{\sigma_2^2\breve{d}^2_{2,\min}}{\sigma_1^2\breve{d}^2_{1,\min}}\right)^{jn_r}}\right) \quad (16)$$

where $d^2_{j,\min} = \sigma_j^2\breve{d}^2_{j,\min}$ with $\breve{d}^2_{j,\min}$ being the normalized minimum distance of the constellation χ_j for $j = \{1,2\}$ and $\mathrm{C}_j^{d_{free}}$ is the binomial coefficient. Note that at high SNR, $(1+N_0) \approx 1$. This expression shows that even in the presence of channel estimation errors, interference-aware receiver achieves full diversity of the system, i.e., $n_r d_{free}$. The coding gain of the receiver increases as the interference signal gets stronger, i.e., σ_2^2 increases or the constellation of the interference signal decreases in size, i.e., $\breve{d}^2_{2,\min}$ increases.

Simulations

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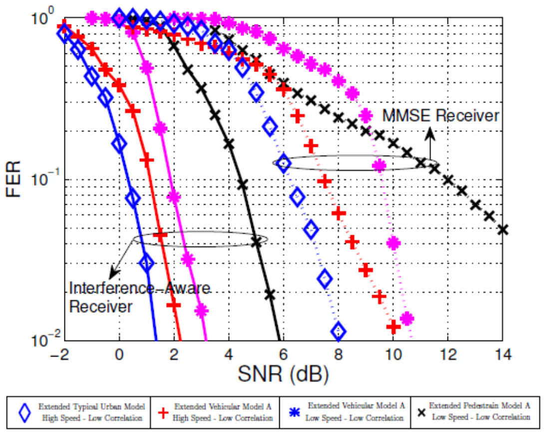

Fig. 1. It shows the case once UE has full CSI. Continuous lines indicate the case of interference-aware receiver while dotted lines indicate the case of MMSE receiver.

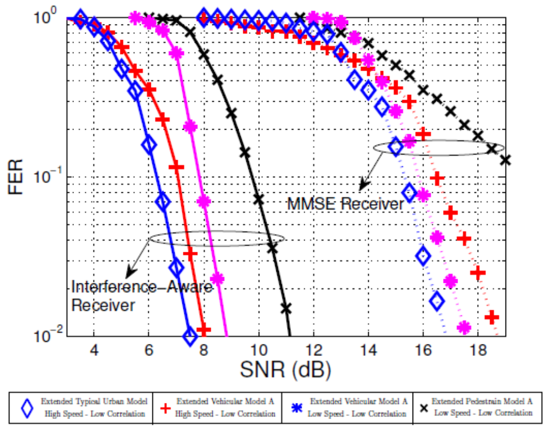

Fig. 2. It shows the case once UE estimates the channel using least squares method. Continuous lines indicate the case of interference-aware receiver while dotted lines indicate the case of MMSE receiver.

Conclusion

TABLE I

Simulation Parameters	
Bandwidth	5 MHz
Sampling Frequency	7.68×10^6
Total Number of carriers	512
Data Carriers	300
Carrier Frequency	1.8 GHz
High Speed	120 km/hr
Low Speed	10 km/hr
Transmit Correlation	$\begin{bmatrix} 1 & \alpha \\ \alpha & 1 \end{bmatrix}$
Receive Correlation	$\begin{bmatrix} 1 & \beta \\ \beta & 1 \end{bmatrix}$
low correlation	$\alpha = 0,\ \beta = 0$
Medium Correlation	$\alpha = 0.3,\ \beta = 0.9$

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