MIMO-OFDM Wireless Communications with MATLAB®

Chapter 12. Vericide kanal bilgisini kullanmak

Yong Soo Cho | Jaekwon Kim

Won Young Yang | Chung G. Kang

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Chapter 12. Vericideki Kanal Bilgisini Kullanmak

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Chapter 12. Vericideki Kanal Bilgisini Kullanmak

12.1 Vericide Kanal Kestirimi

12.1.1 Kanal Simetrisini Kullanmak

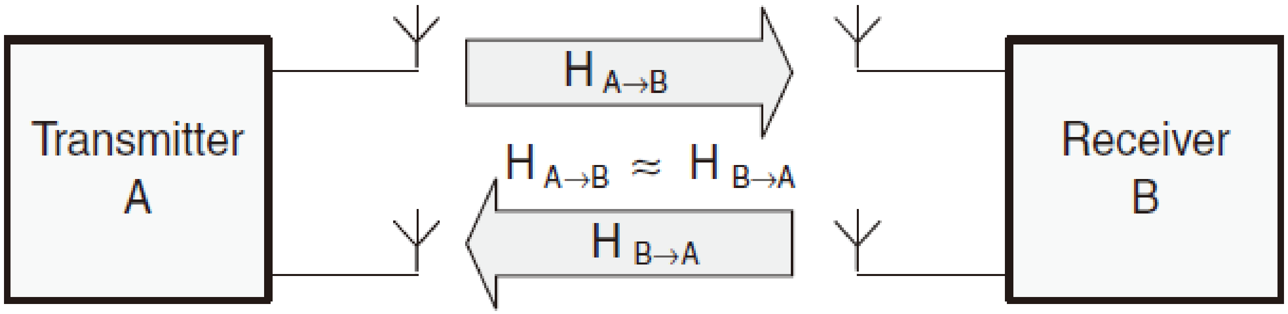

Figure 12.1 Reciprocity of wireless channel.

12.1.2 CSI Geribildirimi

$$\Delta_t = T_c \tag{12.1}$$

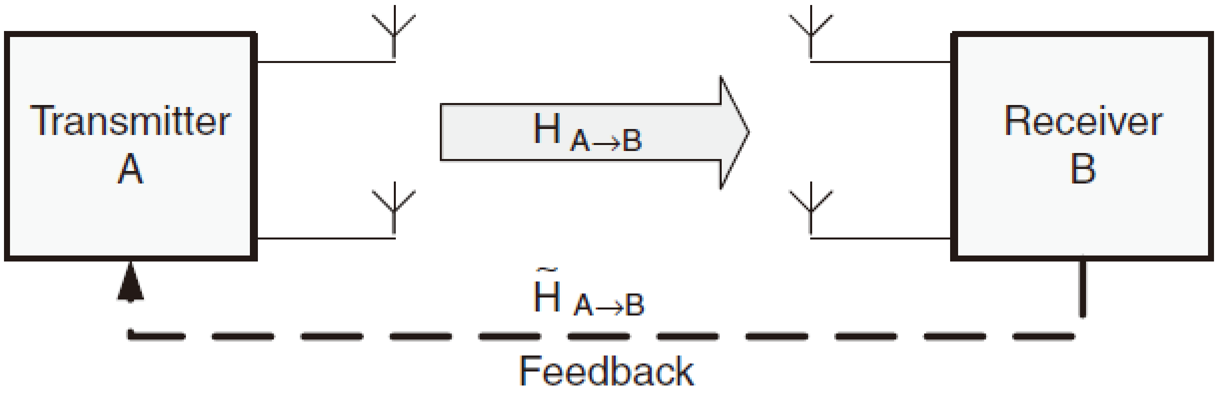

Figure 12.2 Feedback of channel state information.

$$\mathbf{W}_{opt} = f(\mathbf{H}) \in \mathsf{F} = \{\mathbf{W}_1, \mathbf{W}_2, \mathbf{W}_3, \cdots, \mathbf{W}_L\} \tag{12.2}$$

12.2 Ön Kodlamalı Uzay Zaman Kodu

$$\mathbf{y} = \sqrt{\frac{\mathsf{E_x}}{N_T}}\mathbf{hWC} + \mathbf{z} \tag{12.3}$$

$$\Pr(\mathbf{C}_i \to \mathbf{C}_j | \mathbf{H}) = Q\left(\sqrt{\frac{\rho \|\mathbf{HWE}_{i,j}\|_F^2}{2N_T}}\right) \le \exp\left(-\frac{\rho \|\mathbf{HWE}_{i,j}\|_F^2}{4N_T}\right) \tag{12.4}$$

$$\begin{aligned} \mathbf{W}_{opt} &= \underset{\mathbf{W}\in\mathsf{F},i\neq j}{\arg\max} \|\mathbf{HWE}_{i,j}\|_F^2 \\ &= \underset{\mathbf{W}\in\mathsf{F},i\neq j}{\arg\max}\, \mathrm{Tr}\left(\mathbf{HWE}_{i,j}\mathbf{E}_{i,j}^H\mathbf{W}^H\mathbf{H}^H\right) \\ &= \underset{\mathbf{W}\in\mathsf{F}}{\arg\max}\, \mathrm{Tr}\left(\mathbf{HWW}^H\mathbf{H}^H\right) \\ &= \underset{\mathbf{W}\in\mathsf{F}}{\arg\max} \|\mathbf{HW}\|_F^2 \end{aligned} \tag{12.5}$$

12.2 Ön Kodlamalı Uzay Zaman Kodu

$$\mathbf{W}_{opt} = [\mathbf{v}_1 \ \mathbf{v}_2 \ \cdots \ \mathbf{v}_M] \triangleq \bar{\mathbf{V}} \quad (12.6)$$

$$E\left\{\min_{\mathbf{W}\in\mathsf{F}}\left(\|\mathbf{H}\mathbf{W}_{opt}\|_F^2 - \|\mathbf{H}\mathbf{W}\|_F^2\right)\right\}. \quad (12.7)$$

$$E\left\{\min_{\mathbf{W}\in\mathsf{F}}\left(\|\mathbf{H}\mathbf{W}_{opt}\|_F^2 - \|\mathbf{H}\mathbf{W}\|_F^2\right)\right\} \le E\{\lambda_1^2\{\mathbf{H}\}\}E\left\{\min_{\mathbf{W}\in\mathsf{F}}\frac{1}{2}\left\|\bar{\mathbf{V}}\bar{\mathbf{V}}^H - \mathbf{W}\mathbf{W}^H\right\|_F^2\right\} \quad (12.8)$$

$$d(\mathbf{W}_k, \mathbf{W}_l) = \frac{1}{\sqrt{2}}\left\|\mathbf{W}_k\mathbf{W}_k^H - \mathbf{W}_l\mathbf{W}_l^H\right\|_F \quad (12.9)$$

12.2 Ön Kodlamalı Uzay Zaman Kodu

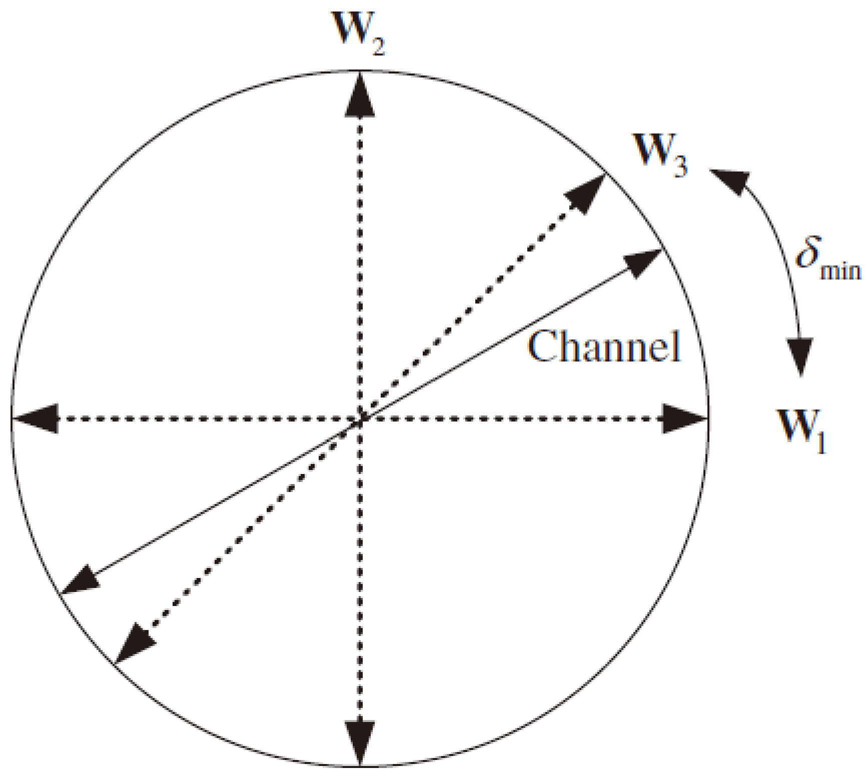

Figure 12.3 Precoding matrix and chordal distance.

12.2 Ön Kodlamalı Uzay Zaman Kodu

$$\mathsf{F} = \{\mathbf{W}_{\text{DFT}}, \boldsymbol{\theta}\mathbf{W}_{\text{DFT}}, \cdots, \boldsymbol{\theta}^{L-1}\mathbf{W}_{\text{DFT}}\} \tag{12.10}$$

$$\boldsymbol{\theta} = \text{diag}\left(\begin{bmatrix} e^{j2\pi u_1/N_T} & e^{j2\pi u_2/N_T} & \cdots & e^{j2\pi u_{N_T}/N_T} \end{bmatrix}\right) \tag{12.11}$$

$$\mathbf{u} = \underset{\{u_1, u_2 \cdots u_{N_T}\}}{\arg\max} \; \min_{l=1,2,\cdots,N-1} d(\mathbf{W}_{\text{DFT}}, \boldsymbol{\theta}^l \mathbf{W}_{\text{DFT}}) \tag{12.12}$$

12.2 Ön Kodlamalı Uzay Zaman Kodu

$$\mathbf{W}_1 = \frac{1}{\sqrt{4}} \begin{bmatrix} 1 & 1 & 1 \\ 1 & e^{j2\pi \cdot 1 \cdot 2/4} & e^{j2\pi \cdot 1 \cdot 3/4} \\ 1 & e^{j2\pi \cdot 2 \cdot 2/4} & e^{j2\pi \cdot 2 \cdot 3/4} \\ 1 & e^{j2\pi \cdot 3 \cdot 2/4} & e^{j2\pi \cdot 3 \cdot 3/4} \end{bmatrix} \qquad (12.13)$$

$$\mathbf{W}_i = \mathrm{diag}\left(\left[e^{j2\pi \cdot 1/4}\ e^{j2\pi \cdot 8/4}\ e^{j2\pi \cdot 61/4}\ e^{j2\pi \cdot 45/4}\right]\right)^{i-1} \mathbf{W}_1\,, \quad i = 2, 3, \cdots, 64 \qquad (12.14)$$

12.2 Ön Kodlamalı Uzay Zaman Kodu

Number of Tx antennas	Number of Data streams	/ Codebook size /(Feedback bits)	Column indices	Rotation vector
2	1	8/(3)	[1]	[1,0]
3	1	32/(5)	[1]	[1,26,28]
4	2	32/(5)	[1,2]	[1,26,28]
4	1	64/(6)	[1]	[1,8,61,45]
4	2	64/(6)	[0,1]	[1,7,52,56]
4	3	64/(6)	[0,2,3]	[1,8,61,45]

Table 12.1 Codebook design parameters for OSTBC in IEEE 802.16e specification.

12.2 Ön Kodlamalı Uzay Zaman Kodu

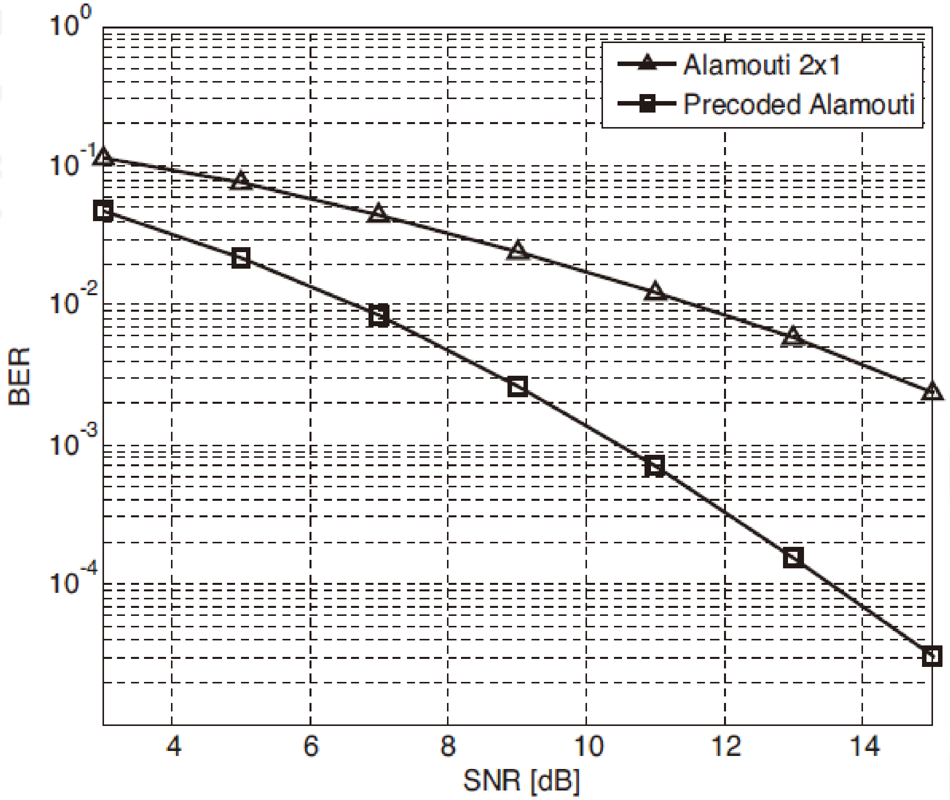

Figure 12.4 BER performance of OSTBC with and without precoding in Rayleigh fading channel.

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Kodlar

- Program 12.1 “codebook_generator” for codebook generation
- Program 12.2 “Alamouti_2x1_precoding.m” for Alamouti coding with precoded OSTBC

12.3 Ön Kodlamalı Uzamsal Çoklama

- Singular value decomposition

12.3 Ön Kodlamalı Uzamsal Çoklama

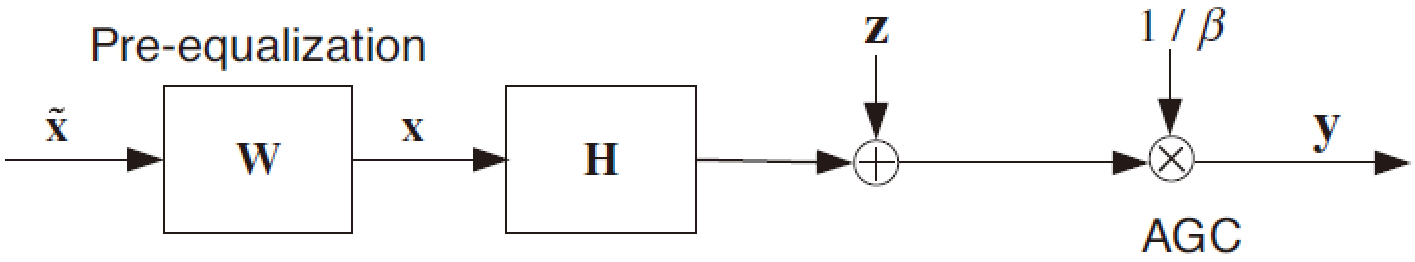

Figure 12.5 Linear pre-equalization.

$$\mathbf{x} = \mathbf{W}\tilde{\mathbf{x}} \quad (12.15)$$

$$\mathbf{W}_{ZF} = \beta \mathbf{H}^{-1} \quad (12.16)$$

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12.3 Ön Kodlamalı Uzamsal Çoklama

$$\beta = \sqrt{\frac{N_T}{\mathrm{Tr}\left(\mathbf{H}^{-1}\left(\mathbf{H}^{-1}\right)^H\right)}}. \tag{12.17}$$

$$\begin{aligned}
\mathbf{y} &= \frac{1}{\beta}\left(\mathbf{H}\mathbf{W}_{ZF}\tilde{\mathbf{x}} + \mathbf{z}\right) \\
&= \frac{1}{\beta}\left(\mathbf{H}\beta\mathbf{H}^{-1}\tilde{\mathbf{x}} + \mathbf{z}\right) \\
&= \tilde{\mathbf{x}} + \frac{1}{\beta}\mathbf{z} \\
&= \tilde{\mathbf{x}} + \tilde{\mathbf{z}}.
\end{aligned} \tag{12.18}$$

12.3 Ön Kodlamalı Uzamsal Çoklama

$$\begin{aligned}\mathbf{W}_{MMSE} &= \beta \times \underset{\mathbf{W}}{\arg\min}\ \mathrm{E}\left\{ \left\| \beta^{-1}(\mathbf{HW}\tilde{\mathbf{x}} + \mathbf{z}) - \tilde{\mathbf{x}} \right\|^2 \right\} \\ &= \beta \times \mathbf{H}^H \left(\mathbf{HH}^H + \frac{\sigma_z^2}{\sigma_x^2}\mathbf{I} \right)^{-1}\end{aligned} \tag{12.19}$$

12.3 Ön Kodlamalı Uzamsal Çoklama

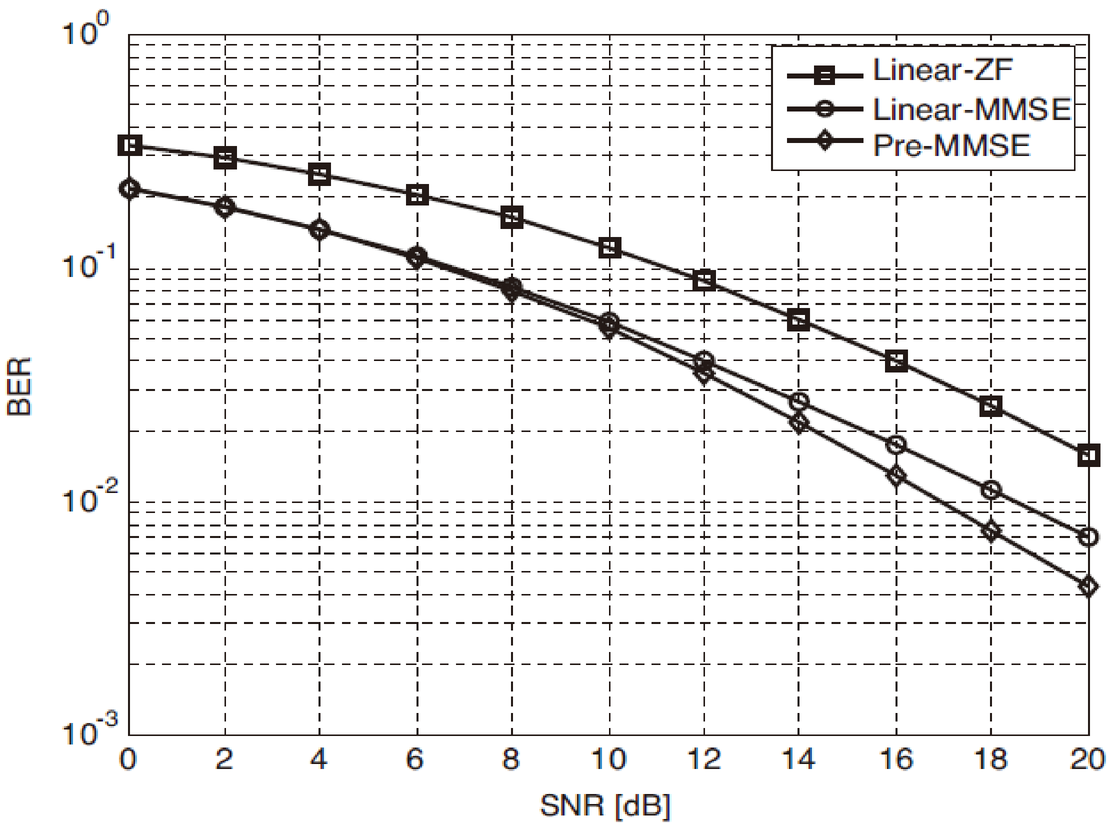

Figure 12.6 Performance comparison: receiver-side ZF/MMSE equalization vs. pre-MMSE equalization.

Kodlar

- Program 12.3 “pre_MMSE.m” for Pre-MMSE equalization

12.4 Anten Seçim Teknikleri

$$\mathbf{y} = \sqrt{\frac{E_x}{Q}}\mathbf{H}_{\{p_1, p_2, \cdots, p_Q\}}\mathbf{x} + \mathbf{z} \qquad (12.20)$$

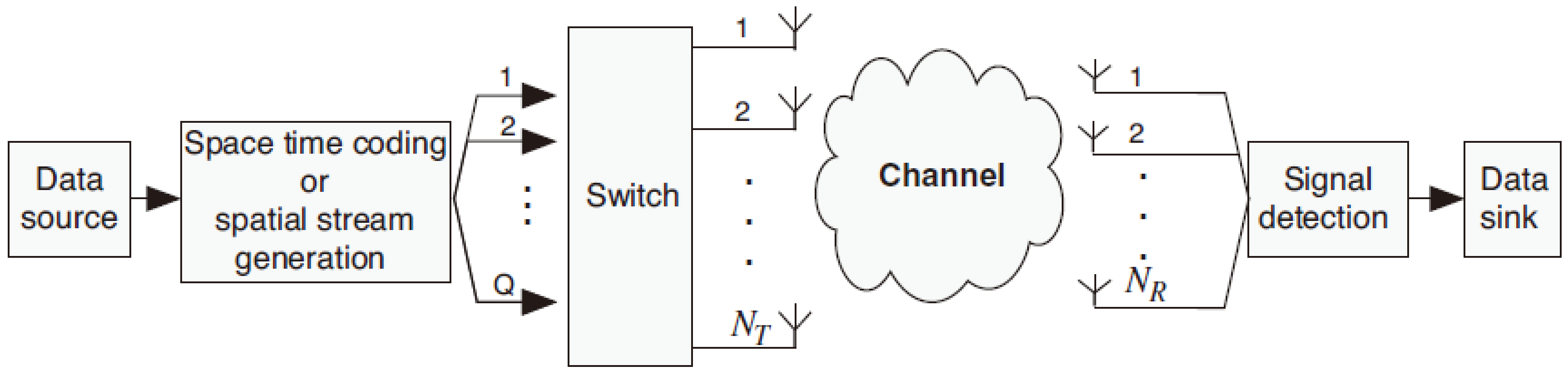

Figure 12.7 Antenna selections with Q RF modules and N_T transmit antennas ($Q < N_T$).