WIRELESS COMMUNICATION

Report on

**Space Time Block codes**

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**Space Time Block Code**

**AIM:** To implement2 transmitter 1 receiver Alamouti space time block code

**SOFTWARE USED:** MATLAB

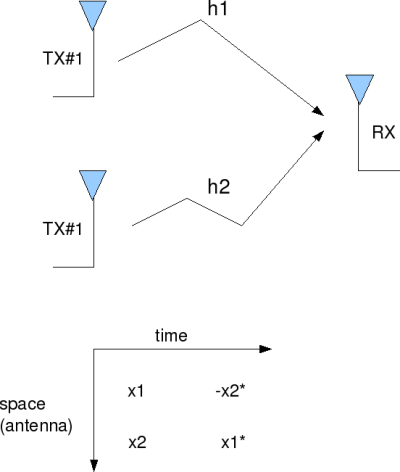
**THEORY:**

A simple Space Time Code, suggested by Mr. Siavash M Alamouti in his landmark October 1998 paper – A[Simple Transmit Diversity Technique for Wireless Communication](http://ieeexplore.ieee.org/iel4/49/15739/00730453.pdf), offers a simple method for achieving spatial diversity with two transmit antennas. The scheme is as follows:

1. Consider that we have a transmission sequence, for example http://www.dsplog.com/cgi-bin/mimetex.cgi?\%7bx_1,%20x_2,%20x_3,%20\ldots,%20x_n%20\%7d

2. In normal transmission, we will be sending http://www.dsplog.com/cgi-bin/mimetex.cgi?x_1in the first time slot, http://www.dsplog.com/cgi-bin/mimetex.cgi?x_2in the second time slot, http://www.dsplog.com/cgi-bin/mimetex.cgi?x_3 and so on.

3. However, Alamouti suggested that we group the symbols into groups of two. In the first time slot, send http://www.dsplog.com/cgi-bin/mimetex.cgi?x_1and http://www.dsplog.com/cgi-bin/mimetex.cgi?x_2from the first and second antenna. In second time slot send http://www.dsplog.com/cgi-bin/mimetex.cgi?-x_2%5e*



and http://www.dsplog.com/cgi-bin/mimetex.cgi?x_1%5e*from the first and second antenna. In the third time slot send http://www.dsplog.com/cgi-bin/mimetex.cgi?x_3 and http://www.dsplog.com/cgi-bin/mimetex.cgi?x_4from the first and second antenna. In fourth time slot, send http://www.dsplog.com/cgi-bin/mimetex.cgi?-x_4%5e* and http://www.dsplog.com/cgi-bin/mimetex.cgi?x_3%5e*from the first and second antenna and so on.

4. Notice that though we are grouping two symbols, we still need two time slots to send two symbols. Hence, there is no change in the data rate.

5. This forms the simple explanation of the transmission scheme with Alamouti Space Time Block coding.

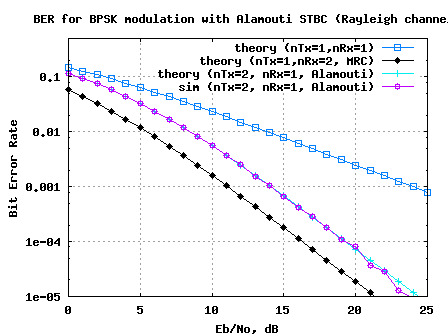
## Other Assumptions

1. The channel is flat fading – In simple terms, it means that the multipath channel has only one tap. So, the convolution operation reduces to a simple multiplication.

2. The channel experience by each transmit antenna is independent from the channel experienced by other transmit antennas.

3. For the http://www.dsplog.com/cgi-bin/mimetex.cgi?i%5e%7bth%7d transmit antenna, each transmitted symbol gets multiplied by a randomly varying complex number http://www.dsplog.com/cgi-bin/mimetex.cgi?h_i. As the channel under consideration is a Rayleigh channel, the real and imaginary parts of http://www.dsplog.com/cgi-bin/mimetex.cgi?h_i are Gaussian distributed having mean http://www.dsplog.com/cgi-bin/mimetex.cgi?\mu_%7bh_i%7d=0 and variance http://www.dsplog.com/cgi-bin/mimetex.cgi?\sigma%5e2_%7bh_i%7d=\frac%7b1%7d%7b2%7d.

4. The channel experienced between each transmit to the receive antenna is randomly varying in time. However, the channel is **assumed to remain constant over two time slots**.



5. On the receive antenna, the noisehttp://www.dsplog.com/cgi-bin/mimetex.cgi?n has the Gaussian probability density function with

http://www.dsplog.com/cgi-bin/mimetex.cgi?p%28n%29%20=%20%5Cfrac%7B1%7D%7B%5Csqrt%7B2%5Cpi%5Csigma%5E2%7D%7De%5E%7B%5Cfrac%7B-%28n-%5Cmu%29%5E2%7D%7B2%5Csigma%5E2%7Dwith http://www.dsplog.com/cgi-bin/mimetex.cgi?%5Cmu=0 and http://www.dsplog.com/cgi-bin/mimetex.cgi?%5Csigma%5E2%20=%20%5Cfrac%7BN_0%7D%7B2%7D.

7. The channel http://www.dsplog.com/cgi-bin/mimetex.cgi?h_i is known at the receiver.

## BER with Almouti STBC

Since the estimate of the transmitted symbol with the Alamouti STBC scheme is identical to that obtained from MRC, the BER with above described Alamouti scheme should be same as that for MRC. However, there is a small catch.

With Alamouti STBC, we are transmitting from two antenna’s. Hence the total transmit power in the Alamouti scheme is twice that of that used in MRC. To make the comparison fair, we need to make the total trannsmit power from two antennas in STBC case to be equal to that of power transmitted from a single antenna in the MRC case. With this scaling, we can see that **BER performance of 2Tx, 1Rx Alamouti STBC case has a roughly 3dB poorer performance that 1Tx, 2Rx MRC case**.

From the post on [Maximal Ratio Combining](http://www.dsplog.com/2008/09/28/maximal-ratio-combining), the bit error rate for BPSK modulation in Rayleigh channel with 1 transmit, 2 receive case is,

http://www.dsplog.com/cgi-bin/mimetex.cgi?P_%7be,MRC%7d%20=p_%7bMRC%7d%5e2\left%5b1+2(1-p_%7bMRC%7d)\right%5d, where

http://www.dsplog.com/cgi-bin/mimetex.cgi?p_%7bMRC%7d=\frac%7b1%7d%7b2%7d-\frac%7b1%7d%7b2%7d\left(1+\frac%7b1%7d%7bE_b/N_0%7d\right)%5e%7b-1/2%7d.

FLOWCHART

End

Find theoretical BER and plot for various SNR

BER=total no. of errors/total no.of bits

Enter the range of SNR to calculate BER.

Perform BPSK modulation on input and Split s as odd and even sequence

Reshape s such that for 2 input sequence,we form a matrix indicating x1 and x2 are sent in 1st timeslot,-x2\* and x1\* are sent in 2 nd timeslot

Generate h and repeat the same for 2 symbols to obtain hmodand Generateawgn noise n

Find received signal y1 and y2 and find y2\* and form equalisation matrix and find demodulated signal

Generate random input sequence of length N

start

With **Alamouti 2 transmit antenna, 1 receive antenna STBC** case,

http://www.dsplog.com/cgi-bin/mimetex.cgi?p_%7bSTBC%7d=\frac%7b1%7d%7b2%7d-\frac%7b1%7d%7b2%7d\left(1+\frac%7b2%7d%7bE_b/N_0%7d\right)%5e%7b-1/2%7dand **Bit Error Rate is**

http://www.dsplog.com/cgi-bin/mimetex.cgi?P_%7be,STBC%7d%20=p_%7bSTBC%7d%5e2\left%5b1+2(1-p_%7bSTBC%7d)\right%5d.

Let us define http://www.dsplog.com/cgi-bin/mimetex.cgi?\mathbf%7bH%7d=%20\left%5b\begin%7beqnarray%7d\%20h_1\%20\%20\%20%20h_2%20\\%20h_2%5e*\%20-h_1%5e*\end%7benarray%7d\right%5d. To solve for http://www.dsplog.com/cgi-bin/mimetex.cgi?\left%5b\begin%7beqnarray%7dx_1%20\\%20x_2%20\end%7beqnarray%7d\right%5d, we know that we need to find the inverse ofhttp://www.dsplog.com/cgi-bin/mimetex.cgi?\mathbf%7bH%7d.

**ALGORITHM:**

1. Enter the range of SNR to calculate BER.
2. Enter the length of message bits N.
3. Generate random input sequence of length N and convert to NRZ polar form s.
4. Reshape s such that for 2 input sequence,we form a matrix indicating x1 and x2 are sent in 1 St timeslot,-x2\* and x1\* are sent in 2 nd timeslot.
5. Separate s as odd and even sequence and then perform reshaping
6. Generate Rayleigh channel parameter and repeat same channel for 2 symbols to obtain hmod.
7. Generate awgn noise n.
8. The received signal in 1 st time slot is y1=h1(-x2\*)+h2x1\*+n.
9. Generate y matrix in this manner [y1 y2 ….yn].

10. Find conjugate of y2,y4..and reshape y.

11. Form equalization matrix .

12.Find modulated signal yhat received.

13.Error=yhat-uncoded bits and find BER.

14.Repeat step 3 to step 12 for different SNR.

15.Plot theoretical vs practical BER for various SNR.

**MATLAB CODE:**

close all;

clear all;

N=input(&#39;enter the length of input bit stream&#39;);

x=randi([0 1],1,N);

t=pskmod(x,2);

h=1/sqrt(2)\*(randn(1,N)+i\*randn(1,N));

n=1/sqrt(2)\*[randn(1,N) + j\*randn(1,N)];

for snr=1:30

sCode = zeros(2,N);

sCode(:,1:2:end)=(1/sqrt(2))\*reshape(t,2,N/2);%[x1 x2..]

sCode(:,2:2:end) = (1/sqrt(2))\*(kron(ones(1,N/2),[-

1;1]).\*flipud(reshape(conj(t),2,N/2)));

hMod = kron(reshape(h,2,N/2),ones(1,2));

y=sum(hMod.\*sCode,1)+10^(-snr/20)\*n;

hEq = zeros(2,N);

hEq(:,[1:2:end]) = reshape(h,2,N/2); % [h1 0 ... ; h2 0...]

hEq(:,[2:2:end]) = kron(ones(1,N/2),[1;-1]).\*flipud(reshape(h,2,N/2));

hEq(1,:) = conj(hEq(1,:)); % [h1\* h2\* ... ; h2 -h1 .... ]

hEqPower = sum(hEq.\*conj(hEq),1);

yMod = kron(reshape(y,2,N/2),ones(1,2));

yMod(2,:) = conj(yMod(2,:));

r = sum(hEq.\*yMod,1)./hEqPower;

r(2:2:end) = conj(r(2:2:end));

r1=pskdemod(r,2);

[num,ratio]=biterr(r1,x);

g(snr)=ratio;

if g(snr)==0

g(snr)=10e-7;

end

end

snr=1:30;

EbN0 = 10.^(snr/10);

theoryBer= 0.5.\*(1-1\*(1+1./EbN0).^(-0.5));

semilogy(snr,g);

hold on;

semilogy(snr,theoryBer);

axis([0 30 0.0000001 1])

legend(&#39;simulated ber&#39;,&#39;theoretical ber&#39;);

xlabel(&#39;snr&#39;);

ylabel(&#39;BER&#39;);

title(&#39;STBC&#39;);

**RESULT:**

2 transmitter 1 receiver STBC was performed in rayleigh using matlab and its BER was calculated.