Subject Name: Wireless Communication

Subject Code: CSP311M

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Practical Number: 4

**Aim:** Write Matlab code of AWGN (Additive white Gaussian noise) and Rayleigh fading for wired network and wireless networks to observe BER to SNR(dB) of each.

**Brief Theory:**

1. **AWGN (Additive white Gaussian noise) (Wired Communication):**

$$X_{bpsk} = 2 * x - 1$$
$$\sigma^2 = 10^{(-SNR/20)}$$
$$n = \frac{1}{\sqrt{2}}\left(randn(1,1) + j * randn(1,1)\right) * \sigma^2$$
$$Y = hX_{bpsk} + n$$
$$BER = \frac{sum(error\ bit)}{total\ no.of\ bits} \quad (\because Practical)$$
$$P_E = \frac{1}{2}\left(erfc\left(\sqrt{SNR_{linear}}\right)\right) (\because Theoretical)$$

Here,
$X_{bpsk}$: $Transmited\ signal\ BPSK$
$x$: $Transmited\ bits$
$n$: $Noise\ Component$
$Y$: $Recieved\ Signal$
$h$: $Complex\ Scaling\ factor (\because h = 1\ for\ wired\ Communication)$
$randn(1,1)$: $random\ number\ generater$
$SNR_{linear}$: $Signal\ to\ Noise\ Ratio\ (linear)$

2. **Rayleigh fading (Wireless Communication):**

$X_{bpsk} = 2 * x - 1$

$\sigma^2 = 10^{(-SNR/20)}$

$n = \frac{1}{\sqrt{2}}\big(randn(1,1) + j * randn(1,1)\big) * \sigma^2$

$h = \frac{1}{\sqrt{2}}\big(randn(1,1) + j * randn(1,1)\big) * \sigma^2 (\because \sigma^2 = 1\ for\ wireless\ comm.)$

$Y = hX_{bpsk} + n$

$BER = \frac{sum(error\ bit)}{total\ no.of\ bits} \quad (\because Practical)$

$P_E = \frac{1}{2}\left(1 - \sqrt{\frac{SNR_{linear}}{1 + SNR_{linear}}}\right)(\because Theoretical)$

Here,

$X_{bpsk}$: $Transmited\ signal\ BPSK$

$x$: $Transmited\ bits$

$n$: $Noise\ Component$

$Y$: $Recieved\ Signal$

$h$: $Complex\ Scaling\ factor$

$randn(1,1)$: $random\ number\ generater$

$SNR_{linear}$: $Signal\ to\ Noise\ Ratio\ (linear)$

## Matlab Code:

1. **AWGN (SNR(dB) -> BER):**

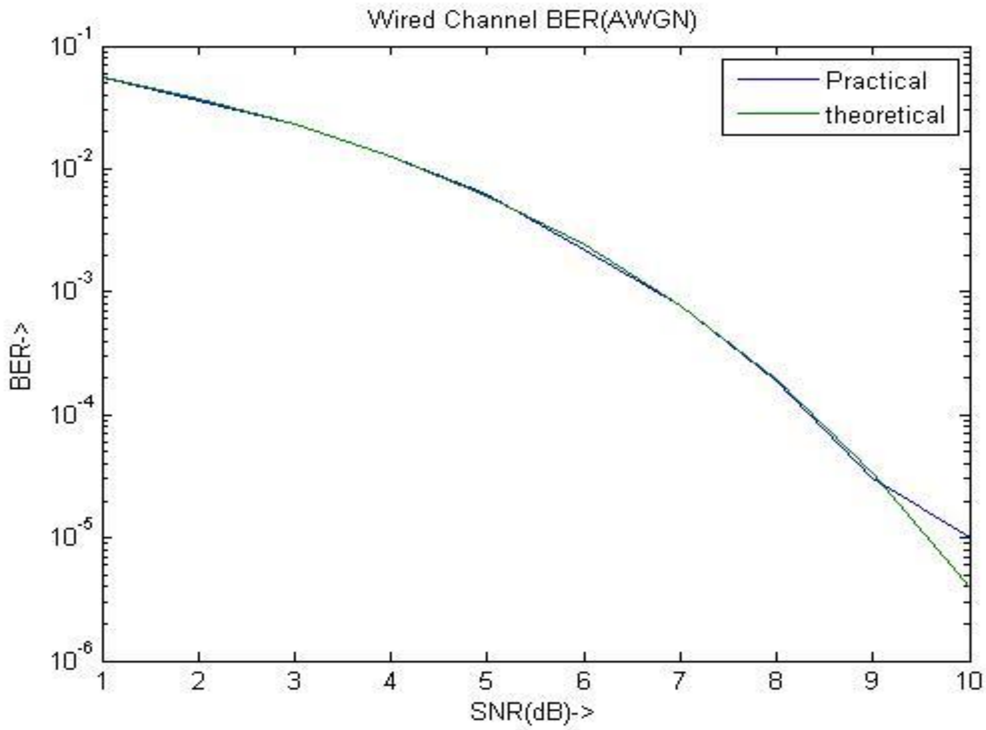
```
%AWGN
% Making Array
Xsym = zeros(1,10^5);
Ysym = zeros(1,10^5);
X = zeros(1,10^5);
n = zeros(1,10^5);
Y = zeros(1,10^5);

for SNR=1:10
    Var = 10^(-SNR/20);

    for i=1:1:10^5
        Xsym(i) = (randi([0,1]));%random number genrater either 0 / 1
        X(i) = 2*(Xsym(i)) - 1;%get value -1 / 1 (BPSK)
        n(i) = (1/sqrt(2))*(randn(1,1)+ randn(1,1)*1j);%noise of output

        Y(i) = X(i) + Var*n(i);%Practical output signal

        if  real(Y(i))<0 %convert recieve symbol in binery
            Ysym(i)=0;
        else
            Ysym(i)=1;
        end
    end

    err_bit = xor(Xsym,Ysym);%to find error
    BER(SNR) = (sum(err_bit)/10^5);%bit error ratio
end
SNR=1:10;%snr values
SNR_linear=10.^(SNR./10);%convert SNR dB to Linear form
PE=1/2.*erfc(sqrt(SNR_linear));%theoretical output signal
semilogy(SNR,BER,SNR,PE);%plot
xlabel('SNR(dB)->');
ylabel('BER->');
legend('Practical','theoretical');
title('Wired Channel BER(AWGN)');
```

**2. Rayleigh fading (SNR(dB) -> BER):**

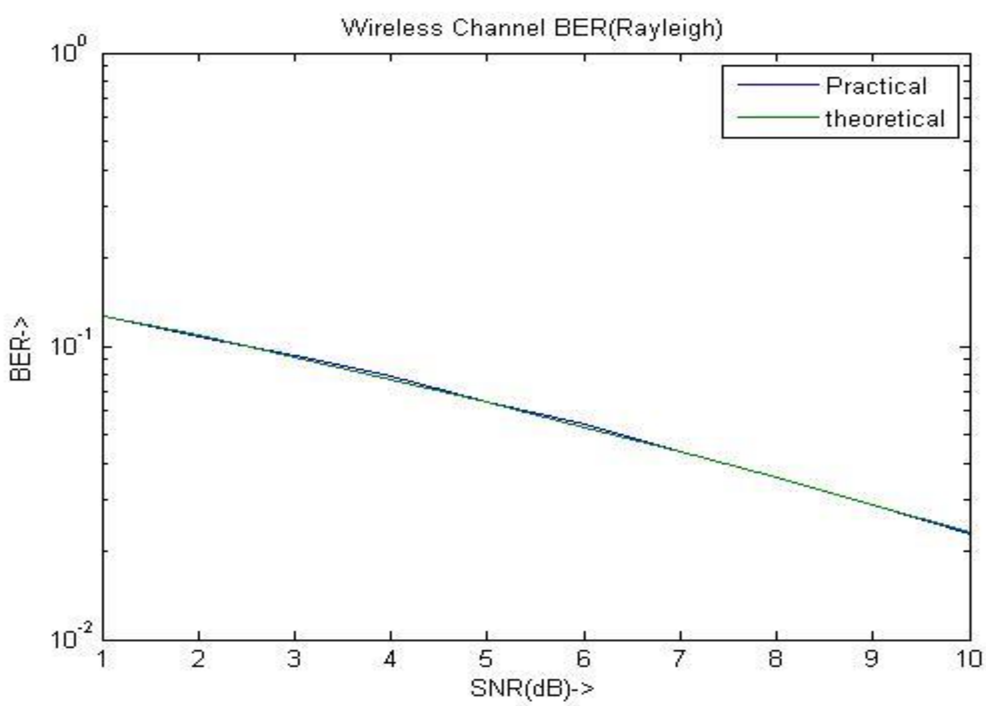
```
%Rayleigh
%making Array
Xsym = zeros(1,10^5);
Ysym = zeros(1,10^5);
X = zeros(1,10^5);
n = zeros(1,10^5);
Y = zeros(1,10^5);

for SNR=1:10
    Var = 10^(-SNR/20);

    for i=1:1:10^5
        Xsym(i) = (randi([0,1])); %random number genrater either 0 / 1
        X(i) = 2*(Xsym(i)) - 1;%get value -1 / 1 (BPSK)
        n(i) = (1/sqrt(2))*(randn(1,1)+ randn(1,1)*1j)*Var;%noise of output
        h = (1/sqrt(2))*(randn(1,1)+ randn(1,1)*1j);%Coefficent factor
        Y(i) = h.*X(i) + n(i);%Practical output signal
        Y(i)=Y(i)./(h);
        if  real(Y(i))<0%convert recieve symbol in binery
            Ysym(i)=0;
        else
            Ysym(i)=1;
        end
    end

    err_bit = xor(Xsym,Ysym);%to find error
    BER(SNR) = (sum(err_bit)/10^5);%bit error ratio
end
SNR=1:10;%snr values
SNR_linear=10.^(SNR./10);%convert SNR dB to Linear form
PE=((1-sqrt(SNR_linear./(1+SNR_linear))))/2;%theoretical output signal
semilogy(SNR,BER,SNR,PE);%plot
xlabel('SNR(dB)->');
ylabel('BER->');
legend('Practical','theoretical');
title('Wireless Channel BER(Rayleigh)');
```

## Output:

1. AWGN (SNR(dB) -> BER):




2. Rayleigh fading (SNR(dB) -> BER):



## Result Interpretation:

BER in wireless communication (Rayleigh fading) is more than the Wired Communication (AWGN) because there is more noise disturbance in wireless communication than wired communication. In General Signal to Noise Ratio Increasing Bit Error Ratio (BER) decrease.