# Data Transfer HW 1

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# 0.1 Question 1

## 0.1.1 A

$P_{tx} = 10$

$Att = -20db$

$P_{rx} =?$

$att = 10 * \log_{10}(\frac{P_{rx}}{P_{tx}}) \Longrightarrow -20 = 10 * \log_{10}(\alpha) \Longrightarrow \alpha = 10^{-2}$

$\alpha = (\frac{P_{rx}}{P_{tx}}) \Longrightarrow (\frac{P_{rx}}{10}) = \frac{1}{100} \Longrightarrow P_{rx} = \frac{1}{10} watt \Longrightarrow P_{rx} = 10^2 mW$

## 0.1.2 B

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# 0.2 Question 2

$TotalAttenuation = -12 + 35 - 10 = 13db$

$+13 = 10 * \log_{10}(\frac{P_{rx}}{4}) \Longrightarrow 10^{1.3} = (\frac{P_{rx}}{4}) \Longrightarrow P_{rx} = 79.8$

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# 0.3 Question 3

## 0.3.1 A

$Nyquist : C = 2 * W * m$

$m = \log_2 M$

$M = 32 \Longrightarrow C = 2 * 10K * \log_2 32 \Longrightarrow C = 2 * 10K * 5 = 100kb/s$

$C = 10^5$

## 0.3.2 B

$C = BW * \log_2(1 + \frac{S}{N}) \Longrightarrow 100K = 10K * \log_2(1 + \frac{S}{N}) \Longrightarrow 10 = \log_2(1 + \frac{S}{N}) \Longrightarrow 2^{10} = 1 + (\frac{S}{N}) \Longrightarrow$

$(\frac{S}{N}) = 1023$

$SNR = 10 * \log_{10}(\frac{S}{N}) \Longrightarrow SNR = 10 * \log_{10} 1023 \Longrightarrow SNR \approx 30db$

### 0.3.3 C

$C_{new} = 2 * C_{old} \Longrightarrow C_{new} = 2 * 100kb = 200kb = 2 * 10^5 b$

$2 * 10^5 = 10^4 * \log_2(1 + \frac{S}{N}) \Longrightarrow 20 = \log_2(1 + \frac{S}{N}) \Longrightarrow \frac{S}{N} + 1 = 2^{20} \Longrightarrow \frac{S}{N} = 2^{20} - 1$

$SNR = 10 * \log_{10} \frac{S}{N} \Longrightarrow SNR = 10 * \log_{10} 2^{20} - 1 \approx 60db \Longrightarrow SNR \approx 60db$

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## 0.4 Question 4

$N = 10mW$

$P_{tx} = 20dbmW \Longrightarrow 10\log_{10} 2 = 20 \Longrightarrow \log_{10} S = 2 \Longrightarrow P_{tx} = 10^2 mW$

$-5 = 10\log_{\frac{P_{rx}}{100}} 10 \Longrightarrow (\frac{-1}{2}) = \log_{P_{rx}} 100 \Longrightarrow 10^{-5} = \frac{P_{rx}}{10^2} \Longrightarrow P_{rx} = 10^{1.5} = S$

$C = BW * \log_2(1 + \frac{S}{N}) \Longrightarrow C = 2 * 10^6 * \log_2(1 + 10^{0.5}) \Longrightarrow C = 2 * 10^6 * \log_2(3.16 + 1) \Longrightarrow C =$

$2 * 10^6 * \log_2(4.16) \approx 4MHz$

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## 0.5 Question 5

$\log_{10}(\frac{E_b}{N_0}) = 4.2db$

$E_b = S * T_b = \frac{S}{R} \Longrightarrow (\frac{E_b}{N_0}) = (\frac{S}{RN_0}) = (\frac{S}{RKT})$

$\Longrightarrow 10\log_{10}(\frac{E_b}{N_0}) = 10\log_{10}(S) - 10\log_{10}(RKT) \Longrightarrow 10\log_{10}(S) = 10\log_{10}(RKT) + 10\log_{10}(\frac{E_b}{N_0}) \Longrightarrow$

$10\log_{10}(S) = 10\log_{10}(RKT) + 4.2 \Longrightarrow 10\log_{10}(S) = 10\log_{10}(270 * 3600 * 1.38 * 10^{-23}) + 4.2 \Longrightarrow$

$10\log_{10}(S) = -164.67 \Longrightarrow \log_{10}(S) = -16.467 \Longrightarrow S = 10^{-16.46} \approx 10^{-16}$

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## 0.6 Question 6

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## 0.7 Question 7

10 Channels + 9 Guard Band : $\Longrightarrow 10*(4)KHz+9*(0.5)KHz = 40+4.5 = 44.5KHz$

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## 0.8 Question 8

### 0.8.1 A

$InFSK : F_g{>}0 \Longrightarrow f_s - \frac{R}{2}{>}0 \Longrightarrow f_s - 1000 > 0 \Longrightarrow f_s > 1000$

$IAssumethat\, f_s = 1200 \Longrightarrow f_g = 200$

$BW = 1200 + 1000 = 2200$

### 0.8.2 B

In ASK : $BW = 2f_0 = R = 2kHz$

### 0.8.3 C

Both FSK and PSK are calculated with the same formula $\Longrightarrow BW = 2f_0 = R = 2kHz$

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## 0.9 Question 9

$10\log_{10}(\frac{E_b}{N_0}) = 10\log_{10}\frac{S}{N} + 10\log_{10}W - 10\log_{10}R \Longrightarrow 18 = 15 + 10\log_{10}\frac{S}{R} \Longrightarrow 3 = 10\log_{10}\frac{W}{R} \Longrightarrow$
$(\frac{W}{R}) = 10^{0.3} \Longrightarrow B = (\frac{R}{W}) = \frac{1}{10^{0.3}} \approx 0.5$

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