Exercise 1: A 100m transmission line has a velocity factor of 0.66. Plot the phase response of the cable over the frequency range 0 to 6 MHz.

$$100m$$

$$v = 2 \times 10^8 \, m/s$$
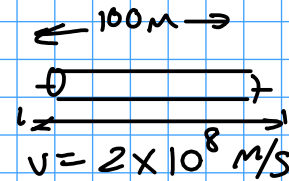
$$\tau = ? = \frac{100}{2 \times 10^8} =$$

$$= 50 \times 10^{-8}$$

$$= 500 \times 10^{-9}$$

$$= 500 \, ns$$

$$2\pi\tau = 2\pi \, 500ns$$

$$\theta(f) = \tau^1 = 2\pi f \tau$$

$$1 = 2 \cdot 500 \times 10^{-9} \cdot f$$

$$f = \frac{10^9}{1000} = 10^6$$

$\angle H(f)$

$\theta(f) = 2\pi f \tau$

1MHz 2MHz 3MHz f

$2\pi\tau$

2π

$-\pi$

-2π τ

500ns

f
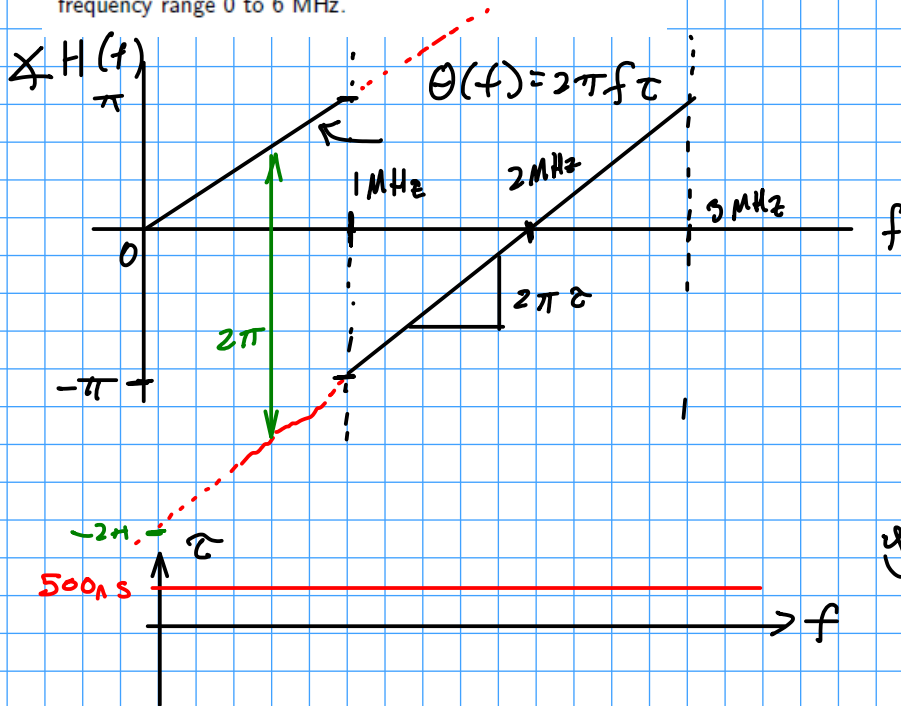
Exercise 2: A telephone line is being used to transmit symbols at a rate of 300 symbols/second. If the group delay must be less than 10% of the symbol period, what is the maximum allowable group delay?

$$T_{symbol} = \frac{1}{300} = 3.3 \, ms$$

$$10\% = 0.1 \times 3.3 = 330 \, \mu s. = \text{max allowable group delay}.$$

Exercise 3: The input to a non-ideal amplifier is the sum of two sine waves at frequencies of 1 and 1.2 MHz. What are the frequencies of the even harmonics of these frequencies? Of the odd harmonics? What are the frequencies of the third-order IMD products?

odd: $1, 3, 5, \ldots \times 1$ or 1.2

even: $2, 4, 6, \ldots \times 1$ or 1.2

$n \cdot 1\text{MHz}$	$m \cdot 1.2\,\text{MHz}$	$IM_3 \, (\text{MHz})$
$\pm 1 \begin{cases} +1 \\ +1 \\ -1 \\ -1 \end{cases}$	$\begin{rcases} +2.4 \\ -2.4 \\ +2.4 \\ -2.4 \end{rcases} \pm 2$	$\begin{matrix} 3.4 \\ -1.4 \\ 1.4 \\ -3.4 \end{matrix}$
$\pm 2 \begin{cases} +2 \\ +2 \\ -2 \\ -2 \end{cases}$	$\begin{rcases} +1.2 \\ -1.2 \\ +1.2 \\ -1.2 \end{rcases}$	$\begin{matrix} +3.2 \\ +0.8 \\ -0.8 \\ -3.2 \end{matrix}$

$\left. \begin{matrix} 0 & 3 \\ 3 & 0 \end{matrix} \right\}$ ignore these

$\begin{matrix} -1 & 4 \end{matrix}$ not negative

(correct lecture notes p.3:

$$f_{IM} = \underbrace{\pm n\, f_1 \pm m\, f_2}_{3}$$
)

Exercise 4: A sinusoidal signal is being transmitted over a noisy telephone channel. The voltage of the signal is measured with an oscilloscope and is found to have a peak voltage of 1V. Nearby machinery in inducing a noise voltage onto the line. The voltage of this noise signal is measured with an RMS voltmeter as 100mVrms. The characteristic impedance of the line is 600Ω and it is terminated with that impedance. What is the signal power? What is the noise power? What is the SNR?

$$P = \frac{V^2}{R} \qquad P = \frac{A^2}{2R}$$

$1 \, V_{peak}:$
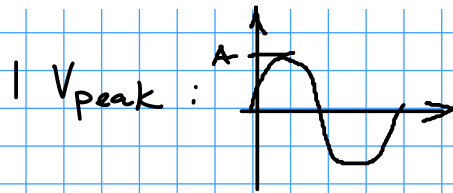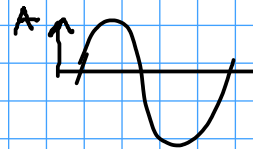
$V = \frac{A}{\sqrt{2}}$

$$P = \frac{V^2}{R} = \frac{A^2}{2R} = \frac{1^2}{2 \cdot 600} = \frac{1}{1200} = 833 \, \mu W$$

$100\,mV_{RMS}:$

$$P = \frac{(0.1)^2}{600} = \frac{10^{-2}}{600} \approx 16 \times 10^{-6}$$

$$SNR = \frac{833}{16} = 50 \, \frac{W}{W}$$

$$SNR\,(dB) = 10 \log 50 = 17 \, dB$$

S = signal

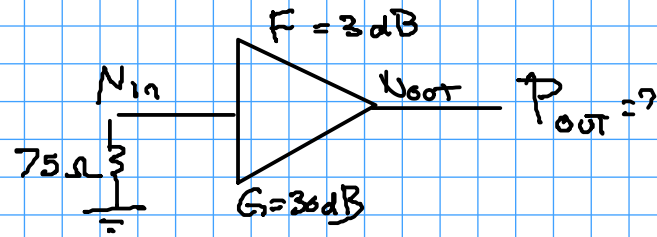I = interference

N = nouse

D = distortion

$$SIR = \frac{S}{I}$$

$$SINR = \frac{S}{N+I}$$

$$SINAD \quad \frac{S}{1+N+D}$$

$$SNR = \frac{S}{N}$$

Exercise 5: A line amplifier for a cable TV system amplifies the range of frequencies from 54-1002 MHz. The amplifier has a gain of 30 dB and a noise figure of 3 dB. If we connect a 75Ω resistor (the input impedance of the amplifier) to the input how much power will we measure at the output of the amplifier?

$F = 3dB$

N_{in} ▷ N_{out} — $P_{out} = ?$

75Ω

$G = 30dB$

$$N = -174 + 10\log(B) + F_{(dB)}$$

$B = 1002 - 54$

$$\approx 1000 \text{ MHz}$$

$$N_{in} = -174 + 10\log(B)$$

$$\approx 10^9 \text{ Hz}$$

$$= -174 + 90 = -84 \text{ dBm}$$

$$\approx 90 \text{ dB-Hz}$$

$$N_{out} = N_{in} + F + G$$

$$= -84 + 3 + 30 = -51 \text{ dBm}.$$

Exercise 6: The output of a noise source has a Gaussian (normally) distributed output voltage. The (rms) output power is 20mW and the output impedance is 100Ω. What fraction of the time does the output voltage exceed 300mV? Hint: the variance (σ^2) of a signal is the same as the square of its RMS voltage.

$$P_{rms} = 20mW \qquad = \frac{V^2}{R}$$
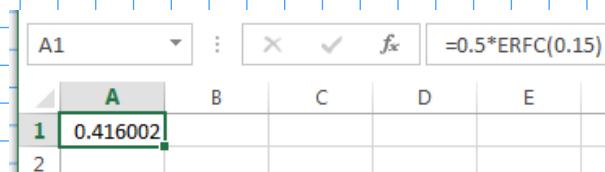
$$V_{rms} = \sqrt{R \cdot P}$$

$$= \sqrt{100 \cdot 0.02} = \sqrt{2} = \sigma$$

assume mean $= 0$

$$\sigma^2 = 2$$

$$P(x > 0.3) = \frac{1}{2} \text{erfc}\left(\frac{0.3}{\sqrt{2} \sqrt{2}}\right)$$

$$= \frac{1}{2} \text{erfc}(0.15) =$$

| | A1 | | ⋮ | ✕ ✓ | f_x | =0.5*ERFC(0.15) |

← MS EXCEL

	A	B	C	D	E
1	0.416002				
2					

pdf = prob. **density** function

Cumulative Distribution Function

pdf

CDF