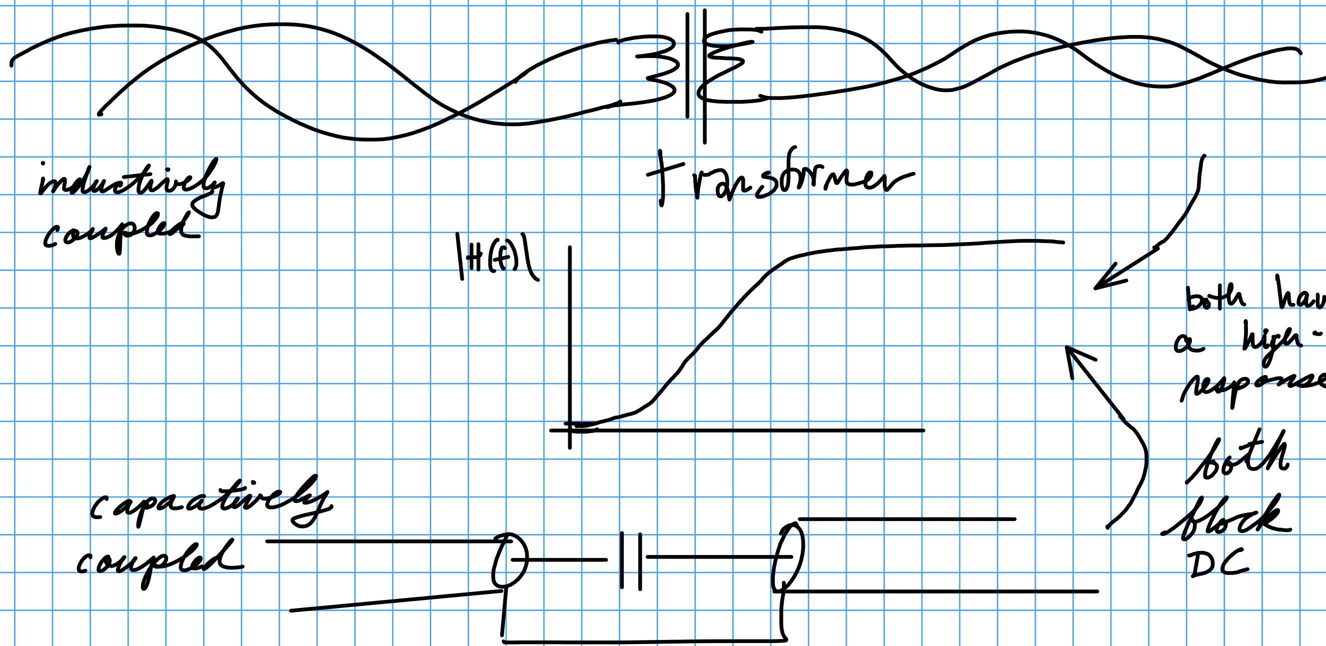
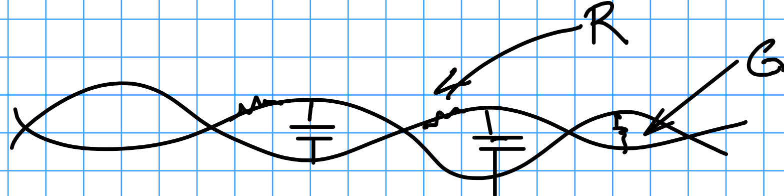
ELEX 3525 - Answers to Lecture 3 Exercise

Examples of High-Pass Channels



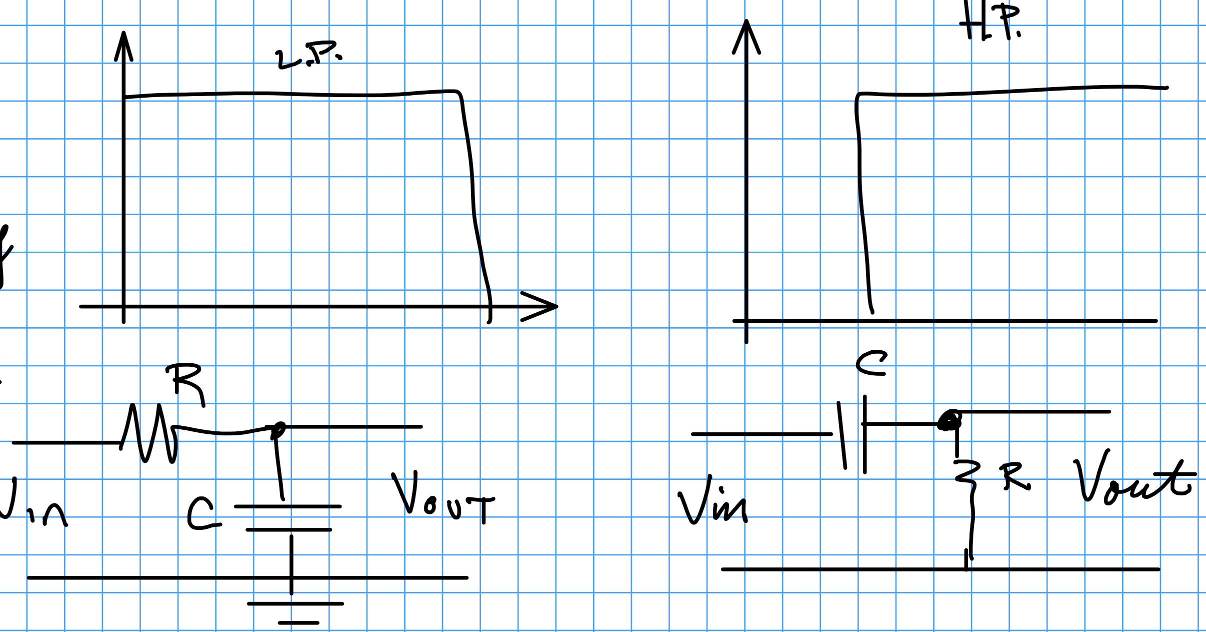
both have a high-pass response

both block DC



lossy elements cause a low-pass response

Examples of simple L.P. & H.P. filters:



limiting condition analysis:
- at high frequencies C is closed circuit
- at low frequencies C is open circuit

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, VF = 0.66

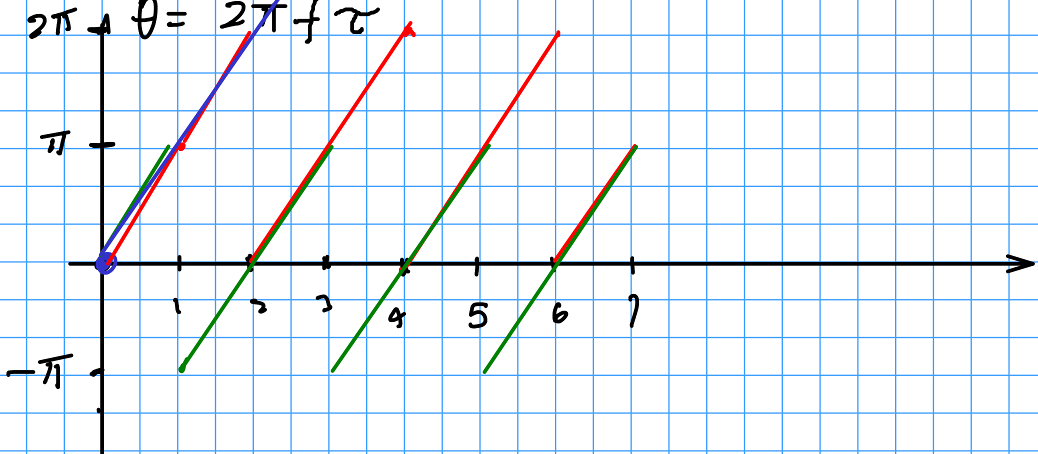
$v = \frac{d}{\tau}$ $\qquad v = 0.66 \cdot c$

$\tau = \frac{d}{v}$ $\qquad = 0.66 \cdot 3 \times 10^8$

$\qquad = 2 \times 10^8$

$\tau = \frac{100}{2 \times 10^8} = 0.5\,\mu s.$

$\theta = 2\pi f \tau$



f (MHz)

for f = 1MHz

$\theta = 2\pi f \tau$

$= 2\pi \cdot 10^6 \cdot 0.5 \times 10^{-6}$

$= \pi$

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?

300 symbols/second

$T = \frac{1}{f} = \frac{1}{300}\,s$

group delay = 10% of T = $0.1\,T$ = $\frac{0.1}{300} \approx 300\,\mu s$

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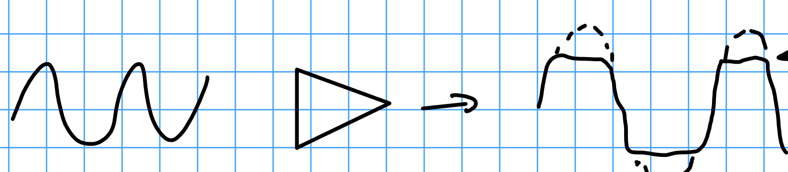
if 4 bits/symbol

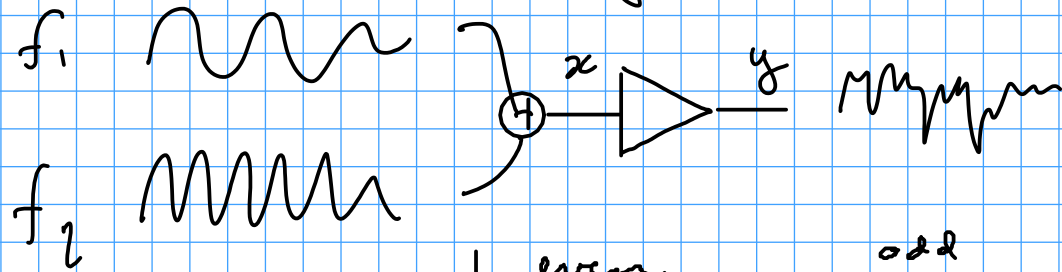
$2^4 = 16$ levels



clipping (a type of N.L. distortion)

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?

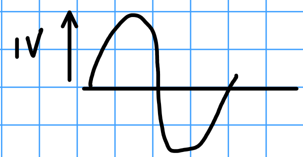
$$y = a + bx + cx^2 + dx^3 + \dots$$

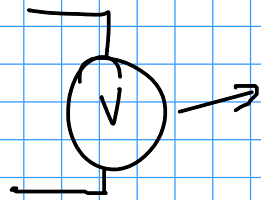


	even harmonics	odd harmonics
$f_1 = 1.0$	2, 4,	3, 5,
$f_2 = 1.2$	2.4, 4.8, ..	3.6, 6, ..

3rd-order $\rightarrow$ $\underset{n}{\pm 1}\ \underset{m}{\pm 2}$ $\qquad$ $\underset{n}{\pm 2},\ \underset{m}{\pm 1}$

n	m	f
+1	+2	$1 + 2 \cdot 1.2 = 3.4$
+1	−2	$1 - 2 \cdot 1.2 = -1.4$
−1	+2	
−1	−2	
+2	+1	
+2	−1	
−2	+1	
−2	−1	$-2 \cdot 1 + -1 \cdot 1.2 = -2 - 1.2 = -3.2$



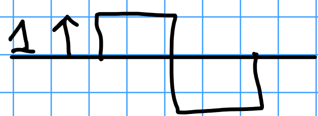


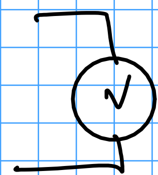
0 — average (DC)

$\frac{1}{\sqrt{2}}$ 0.707 — RMS

1 — amplitude $\underline{A}\cos(\omega t)$

2 — peak-to-peak





average responds — ? not 0.707

RMS → 1 V

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. Why was an RMS voltmeter used? What is the signal power? What is the noise power? What is the SNR?

GIVEN:

signal amplitude = 1V peak

noise voltage = 100 mVrms

$Z_0 = 600\,\Omega$

Q:

- Why RMS voltmeter? → in general we can't measure power of non-sinusoidal signal with non-RMS meter.
- signal power?
- noise power?
- SNR?

V ≡ RMS voltage of sine wave.

$= \frac{1}{\sqrt{2}} \cdot \text{Amplitude}$

$= 0.7 \times 1V = 0.7V_{rms}$

$$S = \frac{V^2}{R} = \frac{(0.7)^2}{600}$$

$$= 833\,\mu W$$

$$N = \frac{V^2}{R} = \frac{(0.1)^2}{600} = \frac{10^{-2}}{600} = 16.67\,\mu W$$

$$\frac{S}{N} = \frac{(0.7)^2}{(0.1)^2} = 7^2 \approx 50 \simeq 17\ ?\ dB$$

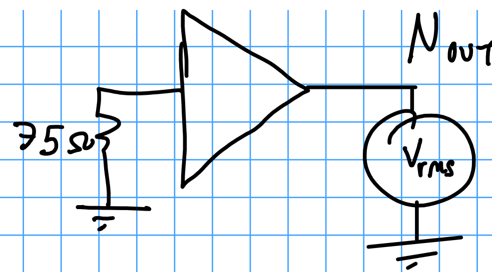
100.00 $\qquad$ 100 ± 1

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?

$B = 1002 - 54 \approx \underbrace{1000\,MHz}_{10^9 \,=\, 90\,dB\text{-}Hz}$

$G = 30\,dB$

$F = 3\,dB$



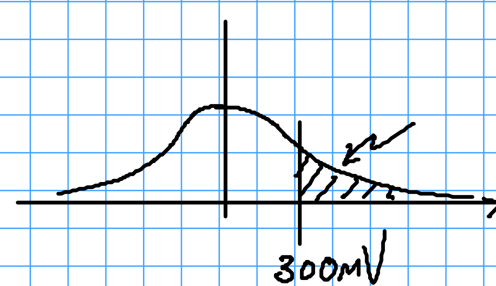
$B\,(dB\cdot Hz) = 10 \log_{10}\left(B_{Hz}\right)$

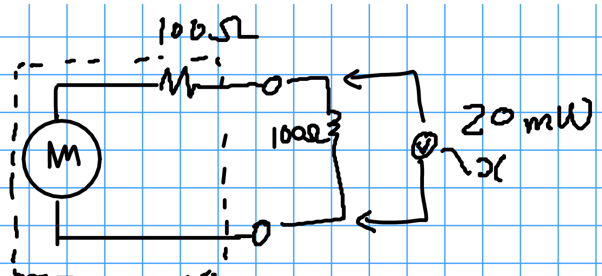
$N_{OUT} = kTBFG$

$= -174 + 90 + 3 + 30$

$= -174 + 123 = -51\,dBm$

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.





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

ASSUME: load impedance is 100Ω

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

$V_{rms} = \sqrt{P \cdot R} = \sqrt{0.02 \cdot 100}$

$= \sqrt{2} = 1.4\,V = \sigma$

$= \frac{1}{2}\,erfc\left(\frac{0.3}{1.4 \cdot 1.4}\right)$

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

Lab 3

'T' & (1 << 2)

"%d"

(1 << 2)

printf("%c", 1 << 2)

0100 → ?

4 → "%d"

'4' → "%c"

0101 0100

'T' & (1 << 2)

```
if (c & (1<<i))
    printf("1");
else printf("0");
```

	x[n]	n
	0	0
0 ←	0	1
1 ←	4	2
	0	3
1 ←	8	4

```
x[n] = c & (1<<n);
x[n] = c & (1<<n) ? 1 : 0;
```

	bm	
0x01	1	
0x02	2	
0x04	4	
0x08	8	
0x10		

c % 2

c = c / 2;