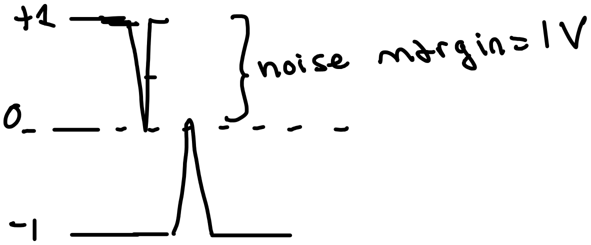
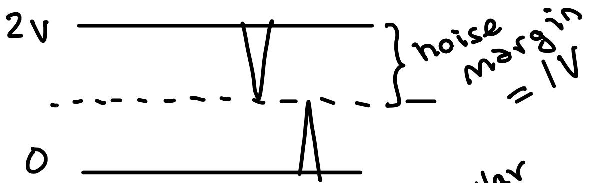
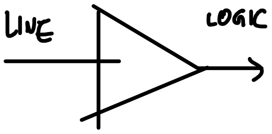
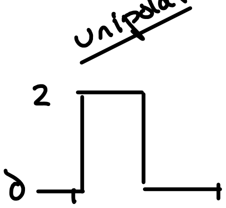
Lecture 6 - Line Codes

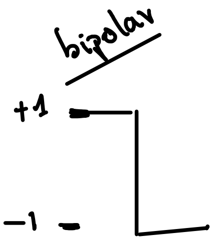
Exercise 1: What is the noise margin for a ~~uni~~ bi polar line code using levels of ±1 V? What are the voltage levels for a ~~bi~~ uni polar lines code with the same noise margin? What are the RMS voltages of these two line codes when transmitting a dotting sequence (alternating 1's and 0's)? Why might you use unipolar line codes anyways?











RMS voltages $= \sqrt{\overline{V^2}}$ $= \sqrt{\frac{2^2+0^2}{2}}$ $\sqrt{\frac{+1^2+(-1)^2}{2}}$

$= \sqrt{2}$ $\sqrt{1}$

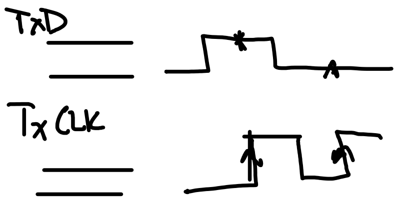
↑ unipolar requires more power

but:

Unipolar line codes are simpler

Exercise 2: A link operates at 100 Mb/s. What is the bit period? The transmitter and receiver have independent clocks (oscillators) with accuracies of 100ppm. What is the maximum difference between the two clock periods in ppm? In seconds?

The timing error due to a frequency (period) difference accumulates over time. How many bits will it take for the accumulated error to equal 10% of the clock period?



200ppm $\frac{200}{10^6}$

$f_b = 100 Mb/s \rightarrow T_b = \frac{1}{100\times10^6} = \underline{10\times10^{-9}} = 10^{-8}s$

max difference = 200 ppm

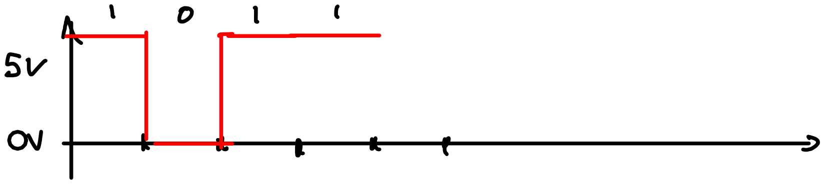
$\underline{200\times10^{-6}} \cdot 10\times10^{-9} = 2000\times10^{-15}$

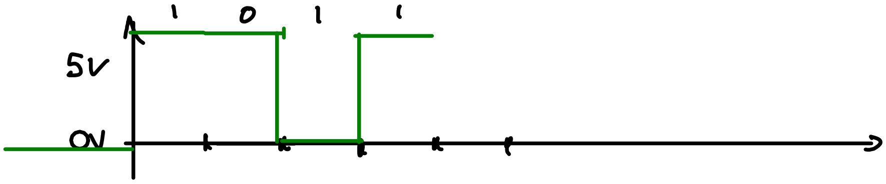
$= 2\times10^{-12}s$ time difference per bit

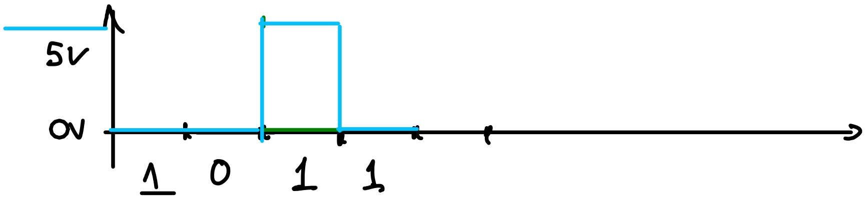
$$\underbrace{10\% \cdot 10^{-8}}\ s = N \cdot \underline{2 \times 10^{-12}}\ s/bit$$

$$N = \frac{10^{-9}}{2 \times 10^{-12}} = \frac{1}{2} \times 10^{3} = 500 \text{ bits}$$

Exercise 3: Assume a 1 is transmitted as 5V and 0 as 0V. Draw the waveform for the bit sequence 1011. Draw the waveform if the bits are transmitted differentially with a 1 encoded as a change in level. Assume the initial value of the waveform is 0. Invert the waveform and decode it.







Exercise 4: How many combinations are there of 3 bits? Of 4 bits? How many bits might be input and output by an 8B10B code? What might a 4B3T code mean?

$$2 \times 2 \times 2 = 2^3 = 8$$

$$2^4 = 16$$

8B10B mean 8 in 10 out

binary

4B3T → Ternary

possible symbols ternary

$$3 \times 3 \times 3 = 3^3 = 27$$

$$\underline{-16}$$

don't use → 11

need 16 of the 27

16

4B	3T
0000	+ 0 -
0001	- - 0

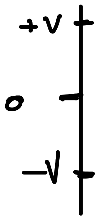
3B4B

IN	OUT
000	1010
001	1001
010	
.	
|	
|	
111	

8	10

8B10B

Exercise 5: Design your own 2B3B line code by choosing the output waveforms that have the lowest average DC value and giving preference to those that start and end at different levels (assume bipolar signalling).



ELEX 3525

2B 3B

00	- - +
01	- + +
10	+ - -
11	+ + -

- - -		~~$\frac{-3}{3} = -1$~~
- - +	✓	$-\frac{1}{3}$
- + -	✗	$-\frac{1}{3}$
- + +	✓	$+\frac{1}{3}$
+ - -	✓	$-\frac{1}{3}$
+ - +	✗	$+\frac{1}{3}$
+ + -	✓	$+\frac{1}{3}$
+ + +		~~$+1$~~

Exercise 6: A data link operates over a distance of 10m at 100 kb/s. If the velocity factor of the cable is 0.66, what is the propagation delay in microseconds? What fraction of the bit period does this represent?

$$\text{delay} = \frac{10\,\text{m}}{0.66 \cdot 3\times10^{8}\ \text{m/s}} = 5\times10^{-8}\ \text{s} = 50\ \text{ns.}$$

$$\text{fraction} = \frac{50\times10^{-9}}{\frac{1}{100\times10^{3}}} = \frac{50\times10^{-9}}{10^{-5}} = 50\times10^{-4} = 0.5\ \%$$

Exercise 7: How would the bit sequence 0110 be encoded using 4B5B followed by MLT3 assuming the starting level is 0V?

$0110 \rightarrow \underline{01110} \rightarrow$