Lecture 7 - Line Codes

Exercise 1: Approximately what bandwidths and center frequencies might be used by each of the following: Telephones? AM broadcasting? Ethernet LAN? A cable TV channel? Which are baseband channels?

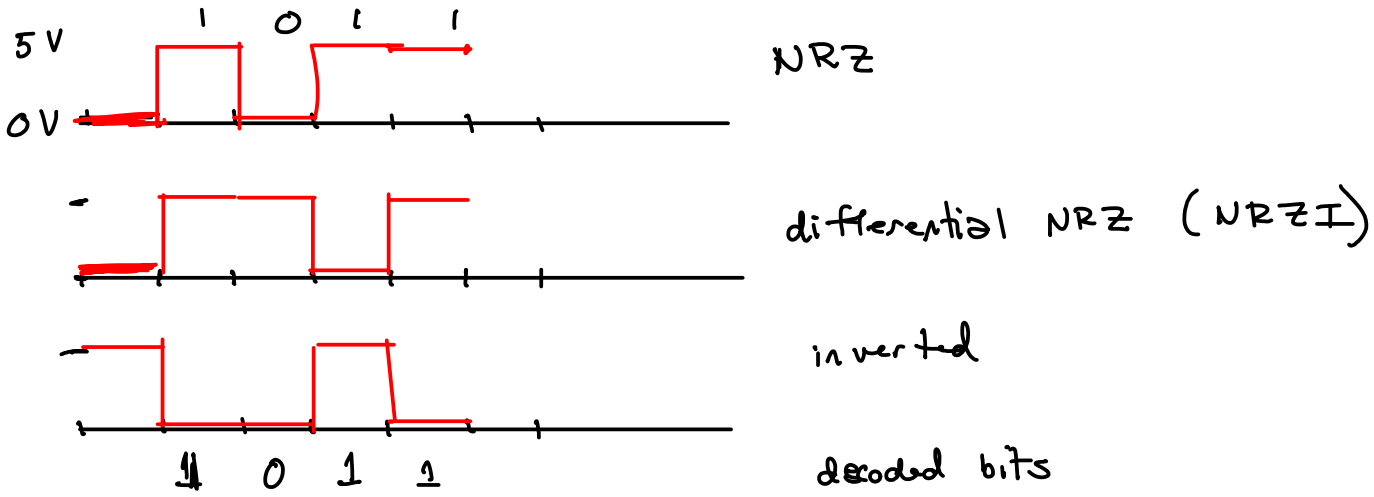
Telephone : 300 – 3 KHz baseband

AM Broadcast : 540 – 1800 KHz passband
B/W ≃ 10 KHz

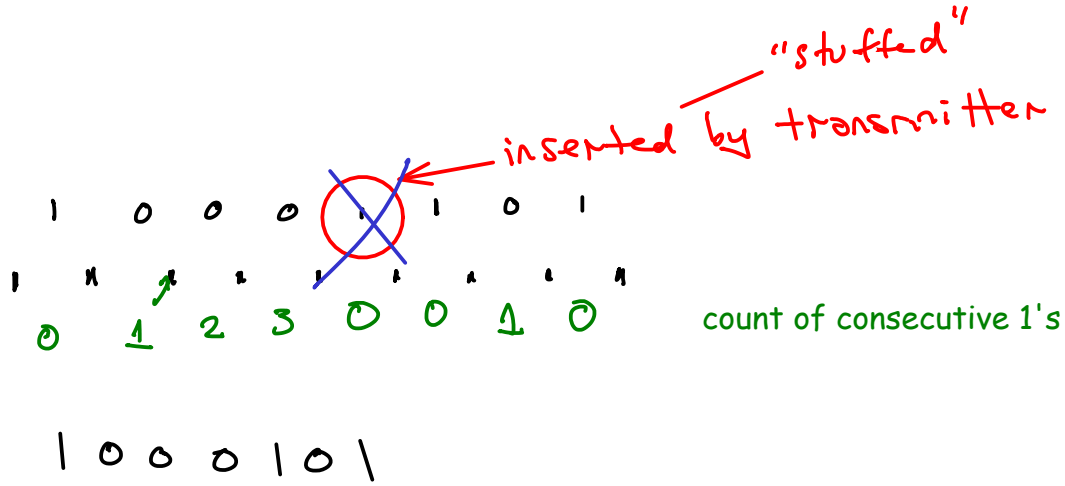
Ethernet : 0 – 100's MHz baseband

Cable TV 50 MHz ⇒ 1 GHz passband
B/W ~ 5 MHz

Exercise 2: 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.

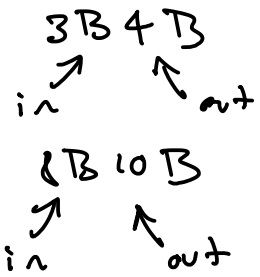


Exercise 3: You receive the sequence of bits 10001101 and are told that bit stuffing was used to limit runs of 0 to three or fewer. What was the original data sequence?



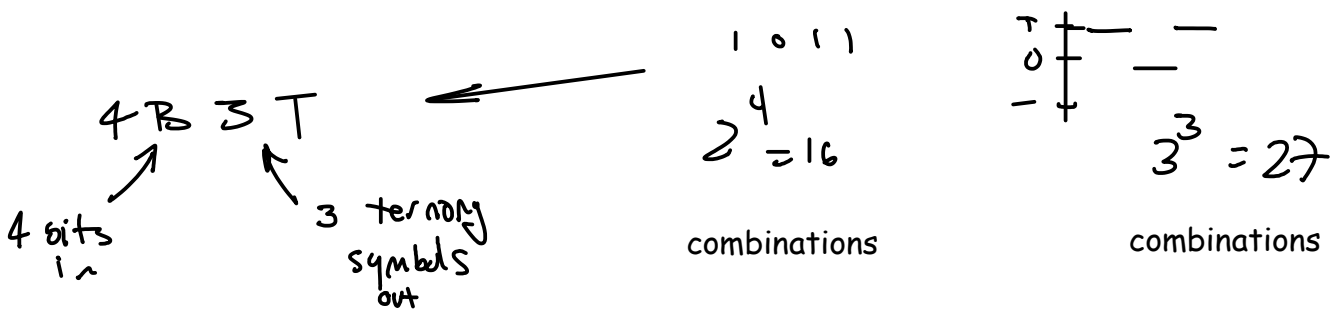
1 0 0 0 1 0 1

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?



3 bits $\Rightarrow 2 \times 2 \times 2 = 2^3 = 8$ combinations

4 bits $= 2^4 = 16$



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).

2B IN	3B OUT
0 0	0 0 1
0 1	0 1 1
1 0	1 0 0
1 1	1 1 0

bipolar NRZ

bits	levels	average (x 3)
0 0 0	−1, −1, −1	~~−3~~
0 0 1	−1, −1, +1	−1 ✓
0 1 0	− + −	−1
0 1 1	− + +	+1 ✓
1 0 0	+ − −	−1 ✓
1 0 1	+ − +	+1
1 1 0	+ + −	+1 ✓
1 1 1	+ + +	~~+3~~

Exercise 6: 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?

(this material not covered)

Exercise 7: What is the probability of having 30 consecutive 1's in a stream of random bits? Of 50 consecutive ones? How often would this happen at a bit rate of 1 Gb/s? (Hint: 1 Gb/s is about 2^{30} bits/second, there are about 2^{25} seconds per year).

Exercise 8: 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?