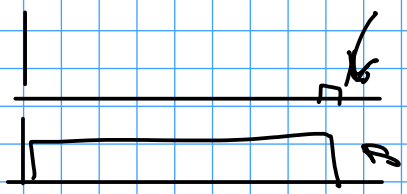
Exercise 1: Approximately what frequencies are used by each of the following: Telephones? AM broadcasting? Ethernet LAN? Cable TV? Which are baseband channels?



telephone: 300 – 3.? kHz minimum –

300 – 8 kHz good.

FM Broadcasting. 85 – 107 MHz ⟶ 200 kHz BW

AM Broadcast 580 – 1600 kHz

Ethernet LAN – 0 – 25 MHz – 100 Mb/s (Baseband).

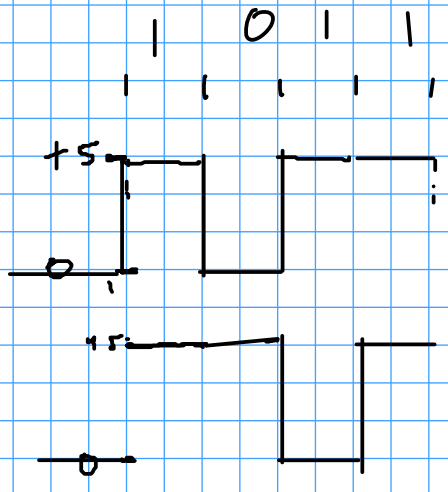
0 – 350 MHz – Gb/s

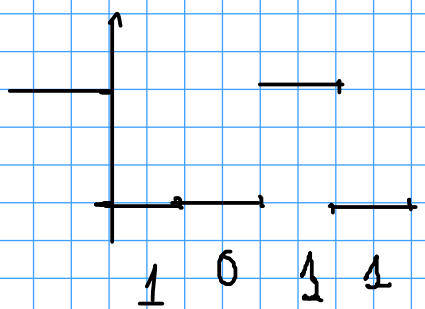
Cable TV – physically 0 ⟶ 1 GHz BASEBAND < upstream / downstream } depends on frq.

TV each channel is only ≈ 5 MHz wide.

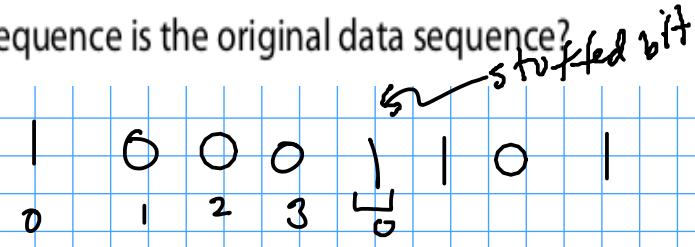
RF or MODULATED SIGNAL

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 sequence is the original data sequence?



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?

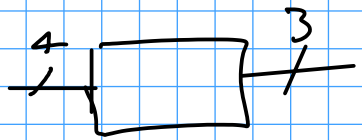
$2 \times 2 \times 2 = 2^3 = 8$ combinations of 3 bits

$2^4 = 16$ combinations of 4 bits

8B 10B ⇒ (8 bits in 10 bits out) (byte)

4B 3T

4 binary bits in
3 ternary symbols out (ternary = 3 values)



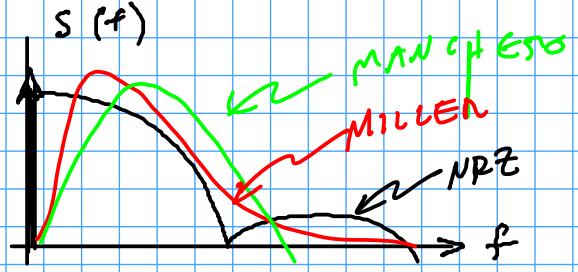
0010

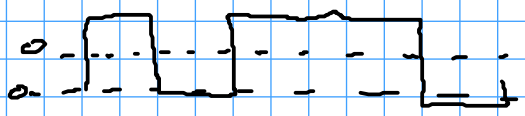
$2^4 = 16$ possible inputs

+5, 0, 0

$3 \times 3 \times 3 = 3^3 = 27$ possible outputs

Exercise 5: 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 error accumulates over time. How many bits will it take for the accumulated error to equal 10% of the clock period?





$$\text{bit period} = \frac{1}{\text{bit frequency}} = \frac{1}{100 \times 10^6}$$

$$= 10^{-8} \quad (10\,ns)$$

worst case difference = 200ppm

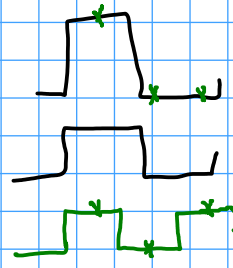
in time 10^{-8}, $200 \times 10^{-6} = 200 \times 10^{-14}$ s

10% of 10^{-8} s is 10^{-9} s

how many clock periods for error to equal 10^{-9}

$$\frac{10^{-9}}{200 \times 10^{-14}} \frac{s}{s/bit} = ? \quad \text{bits}$$

ppm = 10^{-6}
percent = 10^{-2}
p.u. = 10^{0}



Exercise 6: What is the probability of having 100 consecutive 1's in a stream of random bits? How often would this happen at a bit rate of 1 Gb/s? (Hint: 1 Gb/s is about 2^30 bits/second, 1 year has about 2^25 seconds).

Exercise 7: A data link operates over a distance of 10m operates 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?