**Problems - BB codes and synchronization**

**0.** A data flow with a bit rate $D_k = k\cdot 64$kbps should be transmitted over cable with attenuation characteristic $a(f)=6+0.02\cdot f$, f in kHz, knowing that the difference between the margins of the useful bandwidth of the used code should be $\Delta a \leq 6$ dB, the SNR = 20 dB and the transmitted power $P_t = 0$ dBm.
a) Compute the maximum bit rate that can be transmitted using the studied BB codes, what code would provide it, and the value of the noise power density which ensured the imposed conditions.
b) Compute the maximum value S' of the slope of the attenuation characteristic a(f) which would allow the transmission of the maximum bit rate computed at a) using the AMI code, while ensuring the same BER (or the same equivalent SNR)
c) Could the same maximum bit rate be provided by the biphasic code under the same assumptions, except for the slope's value?

**1.** Consider a D = 4800 bps transmission that employs the biphasic-S code and transmits the "101010.." sequence during the synchronization interval.

a) Knowing that the fast synchro operates upon the first 4 stages from the output of the controlled divider, which is the phase shift that has to be compensated by the dynamic synchro? When does the dynamic synchro get into action?
b) Compute the maximum number of stages of the controlled divider in the dynamic synchro, $n_M$, which ensures that the whole synchronization is performed in $t_{sM} = (13/9600)$ s, at most
**c)** How could the $t_s$ be decreased for the circuit configured at a) and b), $n_M$ and m, and what is the minimum value of $t_s$ that could be obtained?

**2.** Consider the fast + dynamic synchronization of a CMI transmission with D = 9600 bps, which transmits the "000…" sequence during the global synchronization time $t_s = (18/38400)$ s at most.

a) Which is the time interval after which the dynamic synchro starts to operate?
b) If the dynamic synchro phase-step $\Delta\varphi_p = (360^o)/64$, which is the number **m** of flip-flops of the controlled divider on which the fast synchro should act upon, to ensure the global synchronization in $t_s$?
**c)** Draw the block diagram of the synchro circuit (fast + dynamic), indicating the number of stages of the controlled divider and the frequencies of the input and output clock signals.

**3.** Consider a CMI transmission with D = 9600 bps, which transmits a "1111.." synchronization sequence.

a) If the fast synchro circuit acts upon the first 4 stages of the controlled divider, which is the maximum phase-shift that is left to be removed by the dynamic synchro? What is the time required by the fast synchro to operate?
b) Which is the maximum value of $f_{atack}$ allowed to ensure the synchronization in $t_s = 8/9600$ s? Which the equilibrium zone ensured (in s)? The dynamic synchro takes no action if the phase reference is missing.
c) Draw the block diagram of the fast + dynamic synchro indicating the frequencies of the input and output clocks and the number of flip-flops.

**4.** a) Consider a biphasic-S transmission with D = 4800 bps, which encodes the "000.." sequence during the synchronization time which has to last $t_{SM} = 950\mu s$ at most. If the variation of the local clock around the ideal position should be $\leq 10\mu s$, compute the minimum possible value of $f_{tack}$, $f_{atack-m}$, and the minimum number $m_m$ of flip-flops upon which the fast synchro circuit should operate to accomplish the synchronization in $t_{SM}$ at most. Show that the computed values are the minimum ones and the correlation between the values of $f_{tack}$ and $m_m$.
b) Compute the minimum value of m if the sequence "0101.." is encoded during the synchronization period.
c) Compute the maximum synchronization time, if $m_m = n-3$, the encoded sequence is "0101…" and $n \geq 4$.

**5.** Consider a D = 38,400 bps BB transmission across a cable with linear a(f) characteristic with a slope S = 0.4 dB/kHz.

a) Knowing that the difference of the attenuations at the margins of useful spectrum of the coded signal $\Delta a \leq 8$ dB, which BB code should be used to ensure D, the smallest bit-error rate and the simplest implementation?
b) What should be the value of S to ensure the same D using the biphasic-S code?
c) If the noise spectral density $N_0$, is the same for a) and b), and the maximum level of the transmission of a) is A, establish the maximum transmitted level A' of the transmission from b) which ensures the same BER?

**6.** Consider a D = 9600 bps BB transmission over a cable with linear a(f) characteristic with slope S = 0.2 dB/kHz, and $N_0$ noise power spectral density. The differences between the margins of the useful spectrum should be $\Delta a \leq 2$ dB.

a) Which is the useful bandwidth of the channel?
b) Which BB code should be employed to ensure D and the smallest BER? Justify by computing the bandwidth of the coded signals and the BER or equivalently the SNRs.
c) What should be the ratio between the levels of the CMI and AMI codes, if the codes ensure the same BER in the transmission above? Note: the BER ~ $\exp[-(1/(M-1))\cdot(P_s/P_z)]$; M – no. of levels of the coded signal.

**7.** Consider a BB transmission with D = 9600 bps.

a) Which is the maximum slope of the linear attenuation-frequency characteristic of the cable to allow the transmission with the AMI code, if the maximum difference of attenuation between the limits of the useful spectrum $\Delta a \leq 5$ dB?
b) Which the maximum bit rate that could be transmitted and which BB code should be used on the cable determined at a), still $\Delta a \leq 5$ dB? Justify by calculus.
c) Which of the two transmissions ensure a higher bit-error rate, assuming that the maximum transmitted level is A for both transmissions? Consider the same $N_0$ for the two transmissions.

**8.** A data flow with a bit rate D= k·15 kbps, k integer, should be transmitted on a twisted-pair cable, characterized by a linear a(f) with the slope S = 0.1 dB/kHz and by a $N_0$ power spectral density of noise.

a) Imposing the difference between the attenuations at the margins of the useful bandwidth to fulfill $\Delta a < 6.4$ dB, establish the maximum bit rate that could be transmitted and the BB code that should be used.

b) If we transmitted the bit rate computed at a) with the biphase-S code that has the same levels of the coded signal, compute the difference between the noise power spectral densities for which this transmission would ensure the same BER as the one ensured by the transmission defined at a)?

c) If the synchronization block of $f_{local}$ used for the transmission defined at a) has a fast synchro block operating on the first three stages of the controlled divider, compute the maximum value of $f_{atack}$ so that the whole synchronization time would fulfill ts $\leq$ 90μs.

**9.** Consider a biphasic-S transmission with D=4800 bps.

a) Knowing that there is no fast synchro circuit and that the dynamic synchro circuit has n= 6 division stages, compute the minimum amount of time in which the local clock of frequency $f_{local}$ can be brought to synchronism. What si the data sequence that has to be transmitted and what is the value of $f_{atack}$ that has to be used?

b) The same questions if between the transmitter and receiver clock oscillators there is a frequency offset $|df| = 0{,}002 \cdot f_{local}$