Problems A+PSK

I. Consider an A+PSK transmission over a radio channel with frequency band FB = [200, 3800]Hz, average attenuation $a_{av}(f)$ = 17 dB and noise power spectral density of -49 dBm/kHz. The maxim allowed level of the average transmitted power is +6 dBm. Assume that $p_e(10.5\text{ dB})\big|_{2\text{-PSK}} = 1\cdot10^{-6}$.

a) If the average transmitted power equals -6dBm and the roll-factor of the RC characteristic is $\alpha \geq 0.2$, compute the maximum bit rate, multiple of 300 bps, that could be transmitted so that $p_e \leq 1\cdot10^{-6}$. Analyze more variants. What is the limit value of BER?
b) Draw the block diagram of the transmitter defined at a), specify the parameters of the constituent blocks and indicate the means to accomplish a constellation invariant to the k·90º rotations of the local carrier.
c) Compute the attenuation inserted by the shaping filter at the transmitter so that the closest spectral lobe outside the useful bandwidth of the signal defined at a) would have a level smaller than -42 dBm. At what frequency should this attenuation be ensured?
d) Draw the block diagram of the receiver for the transmission defined at a) and indicate the parameters of the constituent blocks.
e) If the local carrier is synchronized with a phase offset of +90º, in the above mentioned conditions, what is the maximum number of bit-errors that occur in the first 100 symbols demodulated after the transmission's start?
f) If vectors (3,1) and (1, 1) are transmitted and the channel inserts a phase-hit of +100º during the symbol period of the second vector, compute the number of wrongly demodulated bits.
g) Explain the occurrence mechanisms of the k·90º rotations of synchronized local carrier.
h) What is the minimum „distance" (in Volts) between two vectors from the constellation defined at a), if the channel's characteristic impedance is Z_c = 600 Ω?
i) Which is the SNR value at which the DPSK modulation can provide the bit rate computed at a) with the same p_e maximum value?
j) Indicate a possible mean to double the bit rate computed at a) while observing the same p_e requirement.
k) Which would be the minimum distance between the vectors of the constellation proposed at j)? Justify by calculus.
l) How should the block diagram of the transmitter be modified to implement the constellation defined at j)?
m) But the receiver's block diagram?

II. Consider a channel with the FB = [48 – 72] kHz and a variable SNR ranging between 21 and 32 dB across which bit rates equaling integer multiples of 4800 bps (D_i= k·4800 bps, i integer) are transmitted using square QAM constellations.

a) Establish the maximum bit rates that could be transmitted in this SNR range and their associated SNR domains, if it is requested that $p_e < 1\cdot10^{-6}$ and the same filters should be used for all these bit rates. Indicate the parameters of the employed configurations (f_s, n_i, constellation, α, f_c). Assume that $BER\big|_{2\text{-PSK}}(10{,}5\text{ dB}) = 1\cdot10^{-6} = p_e\big|_{2\text{-PSK}}$. Compute the corresponding nominal spectral efficiencies.
b) Draw the block diagram of the transmitter for the configurations established at a); indicate the parameters of the constituent blocks and the modifications that should be made when the bit rate is changed.
c) Draw the block diagram of the receiver if the carrier recovery is made by using the DDCR method and indicate the modifications that should be made when the bit rate is changed.
d) Explain the occurrence mechanism of the 180º rotation of the synchronized local carrier if it is recovered with the DDCR method.
e) Indicate the method to compensate for the k·90º rotations of the local carrier and compute approximately the maximum number of wrongly decoded bits, out of the first $108\cdot10^6$ transmitted bits, should a k·90° rotation occur, if a the SNR = 27 dB. Analyze the four possible values of k.
f) Compute the maximum bit rates that could be transmitted by using the DPSK modulation on the channel defined above while observing the $p_e < 1\cdot10^{-6}$ requirement. Indicate the constellations that should be used and the SNR domains within which they should be used.
g) Compare the effective bit rates (throughput) θ ensured by the variants established at a) and f) for SNR = 27 dB, if $\theta = D_i\,(1-P_{ep})$ where P_{ep} denotes the error-probability of a packet of L=1024 bits.
h) Establish the maximum D_i that could be accomplished on the same channel by using the 2-FSK modulation.
i) Compute the SNR value which ensures BER = $0{,}25\cdot10^{-6}$, knowing that $BER_{FSK\text{-}ZC} = 0{,}5\cdot e^{-\rho/2}$.
j) Compare the BER performance of the 2-FSK transmission to the ones of the 16-QAM defined at a) using E_b/N_0.
– points h) – j) to be solved at the FSK seminar.

III.

The bit rates D_1 = 14400 and D_2 = 19200 bps should be transmitted on a channel with the FB = [97 – 103] kHz and SNR ranging between (18, 24) dB by using A+PSK constellations so that BER ≤ $0.33\cdot10^{-6}$ should be ensured for D_1 and D_2 at SNRs as small as possible and by using the same filters; Assume that $BER(10{,}5\text{ dB})\big|_{2\text{-PSK}} = 1\cdot10^{-6}$

a) Establish the transmission parameters (n_i, f_s, f_c, α), indicate the constellations employed and compute approximately the SNR domains across which each of the two bit rates D_i should be used.
b) Draw the block diagram of the receiver for the configuration established at a) for D_2 and indicate the parameters of the constituent blocks if the carrier recovery is accomplished with the DDCR method.
c) Compute the average number of L = 1024 bytes-long data blocks that are wrongly demodulated, out of the first 1000 received blocks, if the channel SNR= 20.5 - 21 dB and the local carrier is recovered with a +90º phase-offset.
d) How could the block error rate decreased without modifying the transmission parameters (modulation, frequency band, SNR)?
e) What modification should be made to make the block-error probability smaller than $1 \cdot 10^{-4}$? Disregard the effect of the incorrect carrier recovery.

IV.

Consider a channel with an SNR varying between 19 and 27 dB and the carrier frequency f_c=250 kHz, across which there should be transmitted data flows with bit rates $D_k = k \cdot 9600$ bps, k natural, by using square QAM constellations. The symbol-error probability should be $p_e \leq 1 \cdot 10^{-4}$, and the same filters should be used for all bit rates, and the shaping filters should have $\alpha \geq 0.25$. Assume $BER\big|_{2\text{-PSK}}$ (8,5 dB) = $1 \cdot 10^{-4}$
a) Establish the minimum frequency bandwidth required to transmit maxim possible bit rates D_k in the given SNR range, that values of these bit rates and the SNR domains within which the D_k should be used. Indicate the parameters of the corresponding configurations (f_s, n_k, constellation, α).
b) Draw the block diagram of the receiver for the configuration that provides the highest bit rate established at a); indicate the parameters of the constituent blocks and the modifications that should be made when the bit rate is changed.
c) If the value if the maximum coordinate I_{lM} of the constellation that provides the greatest bit rate D_M established at a) equals I_{lM} = 1,4 V, compute the values of the I_{2m} coordinates of the constellation that provides the minimum bit rate D_m established at a), if the average power of the two constellation should be the same.