

→ Digitalni signal dobimo z pretvarbo analognega govornega signala, kjer uporabimo 8 bitov kvantizacije  $m=8$ .  
 Za pošiljanje dig. signala uporabimo postopek 16QAM.  $BW_k = 16 \text{ kHz}$ .  
 Koliko BW govornega analognega signala lahko prejmemo?  
 $m=4$        $R = m \cdot 16 \text{ kbaud}$

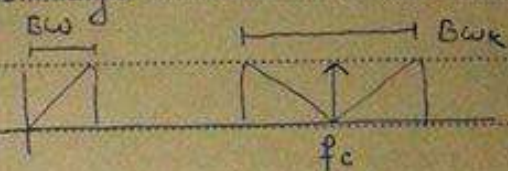
$R = 64 \text{ kbps}$        $f_{max} = \frac{3}{2} = 4 \text{ kHz}$   
 $S = \frac{R}{n} = \frac{64}{8} = 8 \text{ kHz}$        $BW = 4 \text{ kHz}$





a) Premasati izloms govorni signal  $BW = 4 \text{ kHz}$ . Pri digitalizaciji signala uporabimo 8 bitna kvantitacija.

a) kakšno je  $BW_k$  pri AM?



$$BW_k = 2BW = 2 \cdot 4 = 8 \text{ kHz}$$

b) Kakšno  $BW$  kamalo potrebujemo za HBB premo?

$$R = S \cdot m = 2 \cdot 4 \cdot 8 = 64 \text{ kbps}$$

$$S = 2 \cdot f_{\text{max}}$$

$$BW_k = \frac{R}{2} = \frac{64 \text{ kbps}}{2} = 32 \text{ kHz}$$

a) Kakšne bitne hitrosti bi potrebovali za R2 metodo?

$$64 \text{ kHz}$$

c) Kakšne pasovne širine medije so potrebne, če za premo uporabimo 16-QAM pretvorbo?

$$M = 2^m$$

$$R = 64 \text{ kbps}$$

$$m = 4$$

$$R = m \cdot N_{\text{baud}}$$

$$N_{\text{baud}} = \frac{R}{m} = \frac{64}{4} = 16 \text{ kbaud}$$

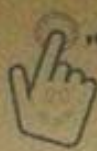
$$\hookrightarrow BW_k = 16 \text{ kHz}$$

d) Kakšno prenosno modulačijo moramo uporabiti da zadostuje  $BW$  kamalo kot je izračunano pod točko a)?

$$BW_k = 8 \text{ kHz} \quad m = \frac{R}{8 \text{ kbaud}} = \frac{64 \text{ kHz}}{8 \text{ kbaud}} = 8$$

$$M = 2^3 = 256$$





PODATKOVNE KODI (analoge)

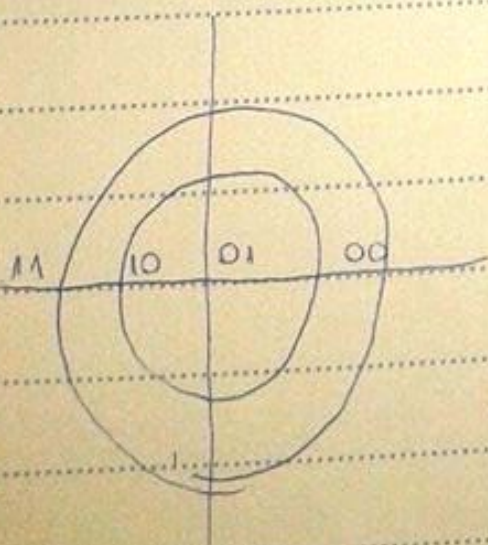
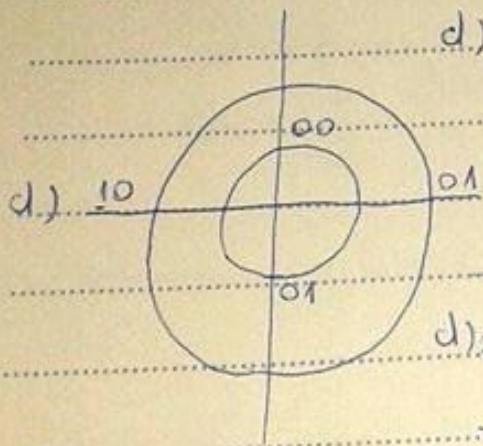
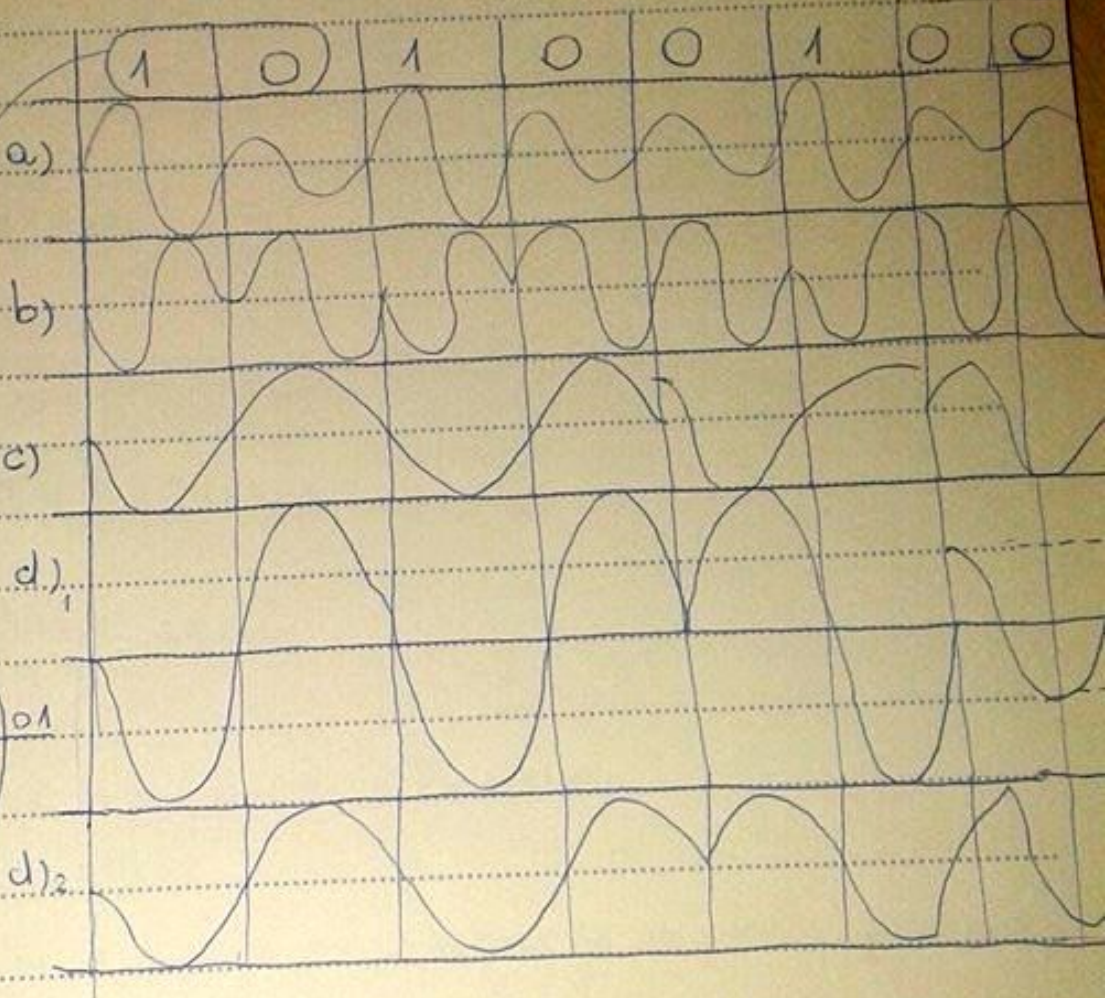
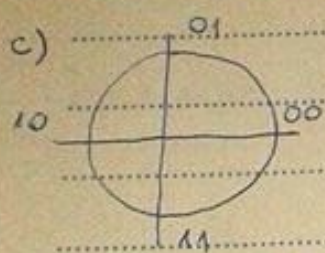
• Narišite turbo bitnega niza 101001002 uporabo:

a) ASK

b) PSK

c) 4-PSK

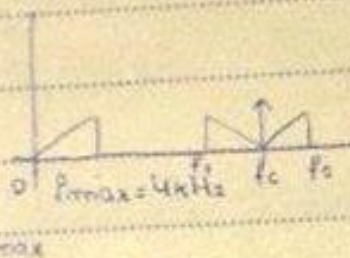
d) 4-QAM







→ Imamo govorni signal z om. pasovne širine 4 kHz. Nariši frekvenčni spekter za AM, kjer je  $f_c = 150$  kHz. Izračunaj BW modul signala.



BW<sub>m</sub> = ?

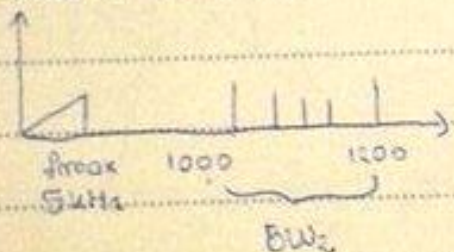
AM,  $f_c = 150$  kHz       $f_1 = f_c - 4$  kHz = 146 kHz

BW = 4 kHz       $f_2 = f_c + 4$  kHz = 154 kHz

$BW_m = f_2 - f_1 = 8$  kHz (2 · BW)

→ Radijska postaja prenaša govorni signal BW = 5 kHz z poslopkom AM

a) Koliko postaj lahko oddaja v frekvenčnem pasu od 1000 kHz do 1200 kHz?

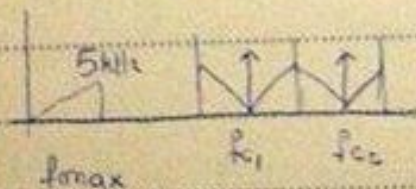


$BW_m = 10$  kHz

$BW_k = 1200$  kHz -  $1000$  kHz =  $200$  kHz

$E = \frac{BW_k}{BW_m} = \frac{200 \text{ kHz}}{10 \text{ kHz}} = 20$

b) kakšne so vrednosti maksimalne frekvence za posamezno postajo?



$f_c = f_1 + 2 \cdot BW = 1015$  kHz

$f_{c1} = f_{min} + BW$

$f_{c1} = f_{min} + BW = 1000$  kHz +  $5$  kHz =  $1005$  kHz

$f_{c2} = f_{c1} + 2 \cdot BW = 1005$  kHz +  $10$  kHz =  $1015$  kHz

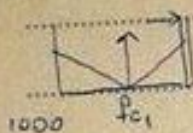
$f_{c3} = f_{c2} + 2 \cdot BW = 1025$  kHz

ve vrednote se povečujejo za 10 (2000)





c.) Koliko postaj lahko oddajajo, če bi uporabljali pas. BW v = 1 kHz <sup>varnostni</sup>



$$BW_m = 10 \text{ kHz} + 1 \text{ kHz} = 11 \text{ kHz}$$

$$E = \frac{BW_k}{BW_m} = \frac{200 \text{ kHz}}{11 \text{ kHz}} = 18$$

d.) kakšne so vrednosti možnih frekvenca za primer pod točko c?

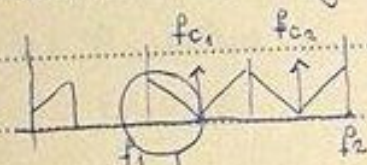
$$f_{c1} = f_{min} + BW = 1000 \text{ kHz} + 1 \text{ kHz} = 1001 \text{ kHz}$$

$$f_{c2} = f_{c1} + 2 \cdot BW = 1001 \text{ kHz} + 2 \text{ kHz} = 1003 \text{ kHz}$$

→ Na voljo imamo prenosni kanal med  $f_1 = 1000 \text{ kHz}$  in  $f_2 = 1016 \text{ kHz}$ ,

ki ga želimo uporabiti za full duplex prenos z am.

a.) kakšna BW signala lahko prenesemo?



$$BW = f_2 - f_1$$

$$BW = 16 \text{ kHz}$$

$$BW_g = \frac{BW}{4}$$

$$BW_g = 4 \text{ kHz}$$

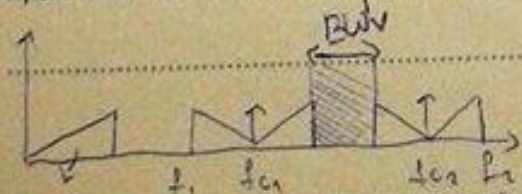
razloži: signal govornep razli;

b.) Izrazi vrednosti obeh nosilcev:

$$f_{c1} = f_{min} + 4 \text{ kHz} = 1004 \text{ kHz}$$

$$f_{c2} = f_{c1} + 2 \cdot BW = 1004 + 8 = 1012 \text{ kHz}$$

c.) kakšno BW govornep signala lahko prenesemo, če upa-  
rabimo varnostni pas BW v = 2 kHz. Izračunaj oba nosilca



$$\text{celotna BW} = 16 \text{ kHz} - BW_v =$$

$$16 - 2 = 14 \text{ kHz}$$

$$14 : 2 = 7 \text{ kHz}$$



$$BW_g = \frac{7 \text{ kHz}}{2} = 3.5 \text{ kHz}$$





DATUM: \_\_\_\_\_

$$f_{c1} = f_c + BW = 1000 + 3,5 \cdot 1003,5 \text{ kHz}$$

$$f_{c2} = f_{c1} + 2BW = 1003,5 + 7 = 1010,5 \text{ kHz}$$

Za podane bitne hitrosti  $R$  in modulatorske postopke izrač. potrebna pasovna širina modula (manjše tudi fazne diagrame)

a)  $R = 4 \text{ kbps}$

postopek ASK  $M = 2$   $m = 1$

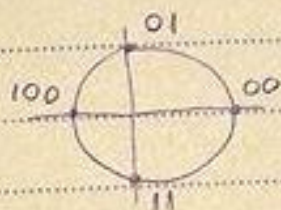
$$M = 2$$

$$R = m \cdot N_{\text{baud}} \quad N = \frac{R}{m} = \frac{4 \text{ kbps}}{1} = 4 \text{ KBpsaud}$$

$$BW = N_{\text{baud}} = 4 \text{ kHz}$$

b)  $R = 6 \text{ kbps}$

4-PSK



$$m = 2$$

$$N = \frac{R}{m} = \frac{6}{2} = 3 \text{ kbaud}$$

$$BW = 3 \text{ kHz}$$

c)  $R = 6 \text{ kbps}$

$$m = 3$$

8-QAM

$$N = \frac{6}{3} = 2 \text{ kbaud}$$

$$BW = 2 \text{ kHz}$$

