25-4-18

Numericals

PCM : Sampling → Quantization

bit rate = no. of samples/sec × bits/sample
(bits/sec)

$$f_s \geq 2f_m$$

Q.1 A speech signal has a total duration of 10 sec, it is sampled at a rate of 8 KHz then encoded with 7 bit binary encoder. Calculate minimum storage capacity, needed to accomodate this digitised signal.

A1. $\nu_s = \frac{1}{10} = 0.1$ Hz

sampling rate = 8000 per sec.
sampling time = 10 sec.

∴ total samples = 80 000 = 8×10^4

Total bits in = $8 \times 10^4 \times 7$
= 560 Kbits

Q2. A PCM uses a uniform quantizer followed by 7 bit binary encoder. The bit rate of the system is 50 Mbps. What is the maximum ~~minimum~~ message bandwidth for which the system operates satisfactorily.

A2. bit rate = 50×10^6 bits per sec.

$$50 \times 10^6 = \text{sample rate} \times 7$$

$$\text{sample rate} = \frac{50 \times 10^6}{7} \leftarrow f_s$$

$$f_m = \frac{f_s}{2}$$

$$\therefore \quad f_m = \frac{25 \times 10^6}{7}$$

$$f_m = 3.57 \times 10^6 \text{ Hz}$$

$$f_m = 3.57 \text{ MHz}$$

$$\therefore \quad W_{max} = 3.57 \text{ MHz}$$

Angle Mod.

Q3. When the carrier sig:

$$V_c(t) = 5 \sin(12 \times 10^5 \pi t) \text{ Volt}$$

is ν modulated by message sig:

$$V_m(t) = 2 \sin(12 \times 10^3 \pi t)$$

the carrier ν varies within 5% of its unmodulated value.

i) What is mod index
ii) " " ν senstivity of modulator
iii) find carson's bandwidth & actual transmission b/w.

A 3. i) mod. index $\mu = \frac{V_m}{V_c} = \frac{5}{2} = 2.5$

~~f_c~~ = $2\pi f t$

$\therefore f_c = 6 \times 10^5$

$V_c(t) = 5 \sin w_c t$
$V_m(t) = 2 \sin w_m t$

$\therefore f_c = 6 \times 10^5$ Hz = 600 KHz
$f_m = 6 \times 10^3$ Hz = 6 KHz

5% of carrier = $\frac{5}{100} \times 600 = 30$
max ν variation

$$\therefore \text{mod. index} = \frac{\Delta f}{f_m} = \frac{30}{6} = 5$$

$$\therefore \boxed{\beta = 5}$$

ii) $$K_f = \frac{\beta f_m}{A_m} = \frac{5 \times \cancel{6}3}{\cancel{2}} = 15 \text{ Hz/volt}$$

iii) $$BW = 2\ \Delta f \left(1 + \frac{1}{\beta}\right)$$

$$= 2 \times 30 \times \left(1 + \frac{1}{5}\right)$$

$$= 2 \times 6 \times 6$$

$$= 72$$

Q4. Consider ~~an~~ a FM wave

carrier, phase part

fm mod. wave → $$f(t) = \cos\left(2\pi f_c t + \beta_1 \sin 2\pi f_1 + \beta_2 \sin 2\pi f_2 t\right)$$

what is max. deviation of instantaneous ν from carrier ν.

A.4. angular $$\nu = \frac{d\theta}{dt}$$

phase angle

ins. ang. ν : $$\omega_i = \omega_c + \frac{d}{dt}\left(\beta_1 \sin 2\pi f_1 + \beta_2 \sin 2\pi f_2 t\right)$$

$$w_i = w_c + \beta_1 2\pi f_1 \cos 2\pi f_1 t + \beta_2 2\pi f_2 \cos 2\pi f_2 t$$

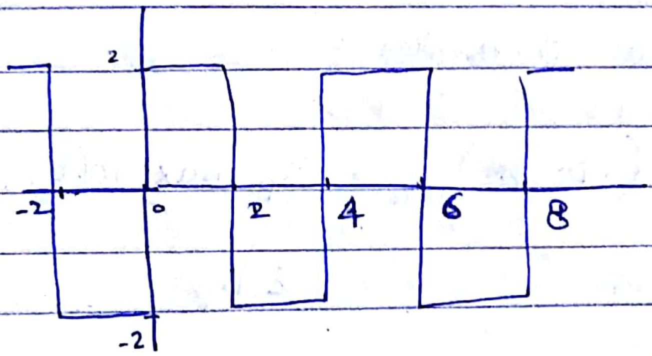
$$\max(w_i) = w_c + 2\pi f_1 \beta_1 + 2\pi f_2 \beta_2$$

$$\max(f_i) = f_c + f_1\beta_1 + f_2\beta_2$$

$\therefore$ max deviation $= f_1\beta_1 + f_2\beta_2$

Q5.

R



~~for a~~ p A signal m(t) ↑ has been applied both to a phase modulator & a ʔ modulator having same carrier ʔ. What is the ratio of K_p/K_f for same max. phase deviation.

A. $\frac{K_p}{K_f}$ ↙ phase sens. rad/Hz

↑ ʔ sens

for a phase mod. the instantaneous value of phase angle is = to the phase of an unmodulated carrier + a time varying component proportional to the modulating signal.

$$\text{ins. ph. angle : } \phi_i = \underset{\uparrow\ \text{init phase angle}}{2\pi f_c t} + k_p\, m(t)$$

max. ph. deviation =

$$(\phi_{i,PM})_{max} = K_p \max m(t)$$

$$= 2K_p$$

$K_f =$

for FM instantaneous value of phase

$$(\phi_{i,FM}) = \omega_c t + 2\pi k_f \int_0^t m(t)\, dt$$

$$(\phi_{i,FM}) = \omega_c t + 2\pi k_F \times 4$$

$$8\pi k_f$$

$$2K_p = 8\pi k_f \qquad \boxed{\therefore \frac{K_p}{K_f} = \frac{8\pi}{2} = 4\pi} \ \text{rad/Hz}$$

27-4-18

Numerical

Q. An angle mod^{d} wave

$$s(t) = \cos\left(2\pi \times \overset{carr}{2\times10^{6}} + 2\pi \times 30 \sin 150t\right) + 2\pi \times 40 \cos 150t$$

find max. ν & phase deviation of s(t).

A1. angular $\nu = \frac{d\theta}{dt}$

instantaneous angle ν : $\omega_i = \omega_c + \frac{d}{dt}\left(2\pi \times 30 \sin 150t + 2\pi \times 40 \cos 150t\right)$

$$\omega_i = \omega_c + 2\pi \times 30 \times 150 \times \cos 150t - 2\pi \times 40 \times 150 \times \sin 150t$$

$$\max(\omega_i) = 2\pi \times 2\times10^{6} + 2\pi \times 30 \times 150 + 2\pi \times 150 \times 40$$

$\omega = 2\pi\nu$

$$= 2\pi\left(2\times10^{6} + 4500 + 6000\right)$$

$$= 12,632,344.060$$

$$= 12.632 \text{ MHz}$$

$S = \lambda$ ~~time~~ $\frac{45}{60}$ 4

$v = f\lambda$

$20 \times 10^2 \times 10^3$

$$\max(\omega_1) = 2\pi\left(2\times10^6 + 4500\cos 150t - 6000\sin 150t\right)$$

~~$= 2\pi\left(20\times10^2\times10^3 + 1\right.$~~

$$= 4\pi\times10^6 + 1500\times 2\pi\left(3\cos 150t + 4\sin 150t\right.$$

$$= 4\pi\times10^6 + 3000\pi\left(3\cos 150t - 4\sin 150t\right)$$

$\max = \sqrt{3^2+4^2}$

7.5 KHz $= 4\pi\times10^6 + 3000\pi\times5$

$= 4000000\pi + 15000\pi$

$= 12.6$ MHz