Ajay Kumar Garg Engineering College, Ghaziabad

Department of ECE

Model Solution Sessional Test-2

Course:	B.Tech	Semester:	V
Session:	2017-18	Section:	EC-1, 2, 3
Subject:	Principle of Communication	Sub. Code:	NEC-502
Max Marks: 50		Time:	2 hour

Note : Answer **all** the sections.

Prepared By: Abhijeet Upadhya

Section A

1. Write expression of A-Law companding.

Ans. For positive voltages

$$y = \begin{cases} \frac{A}{1+\ln A}\left(\frac{m}{m_p}\right) & ; \quad 0 \leq \frac{m}{m_p} \leq \frac{1}{A} \\ \frac{1}{1+\ln A}\left(1+\ln A\frac{m}{m_p}\right) & ; \quad \frac{1}{A} \leq \frac{m}{m_p} \leq 1 \end{cases}$$

2. Write exact data rates of T1 carrier system Hierarchy.

Ans.

PCM transmission	64 kbps
24 PCM signals	1.544 Mbps
7 T-1 signals	6.312 Mbps
3 T-2 signals	44.736 Mbps

3. Why non-uniform quantization is preferred over uniform quantization.

Ans. Since, uniform quantization uses equal number of steps (levels) for complete signal. Sometimes it is required to follow signal variations closely by changing the step size.

4. Write steps of converting a signal from analog to digital.

Ans. Following processes are involved :-

Sampling $\rightarrow$ Quantization $\rightarrow$ Encoding

5. Why thermal noise acts as an important factor affecting output power in PCM technique.

Ans. Maximum quantization error for step size Δ is given as $\pm \frac{\Delta}{2}$ volts.

With thermal agitation of electrons, the SNR of system changes, and quantization noise is increased.

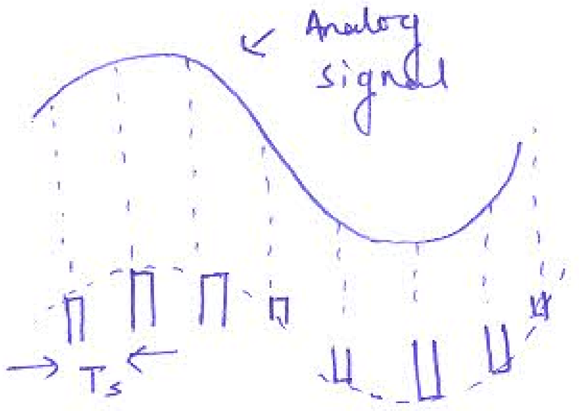
Section B

6. Derive expression of flat-top sampling with required block diagram.

Ans. Sampling process can be of one of two types

(a) Natural sampling (b) Flat-Top Sampling.

The adjoining figure illustrates flat-top sampling.



Mathematically, we can consider flat-top sampling by convolving pulse sequence $p(t)$ with $x_\delta(t)$

$$x_s(t) = p(t) * x_\delta(t)$$
$$= p(t) \left[\sum x(kT_s)\, \delta(t - kT_s) \right]$$

$$X_s(f) = P(f) \cdot f_s \sum X(f - nf_s)$$

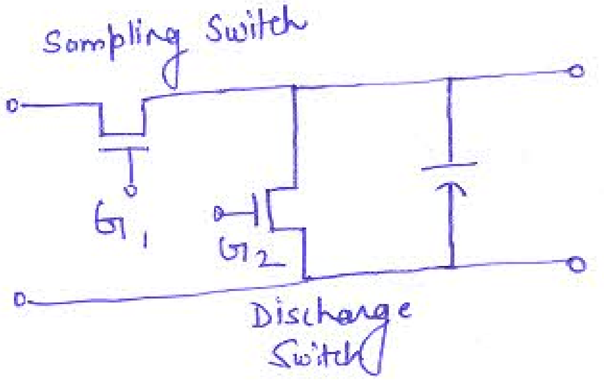


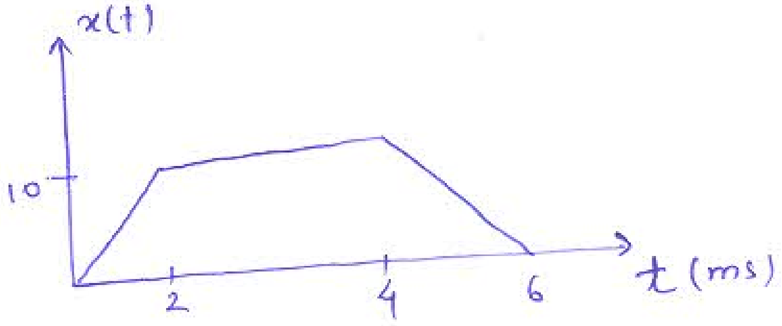
Fig: Flat Top Sampling Scheme.

7. A modulating signal $x(t)$ with a trapezoidal waveform as shown in Fig. 1 is used for

(a) FM a carrier signal of 2 MHz frequency with a frequency deviation constant k_f of 5 kHz/V.

(b) PM with k_p of 5 rad/V.

In each case, find max^M inst. frequency.



Ans. (a) Considering FM

$$y(t) = A_c \cos\left[\omega_c t + k_f \int m(\lambda)\,d\lambda\right]$$

$$\omega_i = \frac{d}{dt}\theta(t) = \omega_c + m(t)$$

But $m(t)\Big|_{max} = 10\,V$

$$\therefore f_i = 2005\ \text{kHz}$$

(b) Considering PM

$$y(t) = A_c \cos\left[\omega_c t + k_p\, m(t)\right]$$

$$\omega_i = \frac{d}{dt}\theta(t) = \omega_c + \frac{d}{dt}m(t)$$

$$\frac{d}{dt}m(t)\Big|_{max} = 10\,\delta(t-2)\times 10^{3} \quad \left\{\because \frac{10}{10^{-3}} = \frac{y}{x}\right\}$$

$$\therefore f_i = 2007.96\ \text{kHz}$$

8. For the FM wave expression given below, find the following :-

$$y(t) = 5\cos\left[2\pi 10^6 t + 3\sin 2000\pi t\right]$$

(a) Power content in FM signal.

(b) Maximum phase deviation and maximum freq. deviation if the carrier frequency is 1 MHz.

(c) Determine the approximate bandwidth of FM signal.

Ans. (a) Power content of

$$A_c \cos[\omega_c t + k_p m(t)]$$

or

$$A_c \cos\left[\omega_c t + k_f \int m(\lambda)d\lambda\right]$$

is $\frac{A_c^2}{2} = \frac{5^2}{2} = 12.5$ watts.

(b) $\theta(t) = \omega_c t + k_p m(t)$

Maximum Phase deviation $= k_p$

$$\Delta\phi = 3 \text{ rad.}$$

Maximum frequency deviation $= \left.\frac{d\phi}{dt}\right|_{max}$

$$\Delta f|_{max} = 3\text{ kHz}$$

(c) Bandwidth of FM signal is approximated by Carson's Rule

$$f_B = 2(f_m + \Delta f_{max})$$

$f_m = 1\text{kHz}$

$$\therefore f_B = 8\text{ kHz}$$

9. Explain direct methods of FM generation with their different types.

Ans. FM set-ups where we apply the modulating signal and the output is modulated signal are said to fall in the category of "direct" FM modulators.

Further, any device that can change the resonant frequency with changing signal is sufficient enough to directly modulate the signal:-

(a) Tank Circuit Approach:-

Parallel combination of passive components L, C, R resonant at fo given by

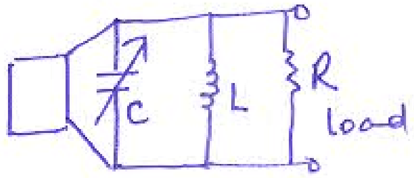
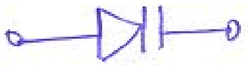


Fig: Microphone

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

By either varying 'C' or 'L' with m(t), FM may be generated. In depicted microphone, 'C' is varied in a transducer.

(b) Varactor Diodes :- Varicap (variable capacitor) are generally employed for FM generation in direct methods.



symbol of Varicap

By changing the depletion region when a reverse bias is applied, the capacitance offered by varicap is changed. When applied to tank circuit or to any oscillator circuit direct FM may be generated using Varicap.

10. Explain Armstrong's Method of Indirect FM generation.

Ans. Armstrong's method uses two stages for FM generation :-

(a) Narrowband FM generation (NBFM)

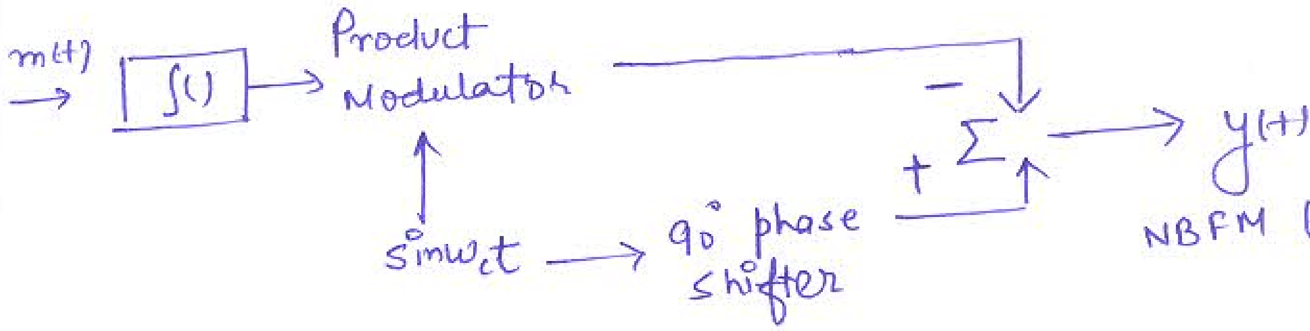
If $y(t) = \cos[\omega_c t + m(t)]$

$= \cos(\omega_c t) \cdot \cos(m(t)) - \sin(\omega_c t) \cdot \sin(m(t))$

when $|m(t)| << 1$

$$y(t) \simeq \cos\omega_c t - m(t) \sin(\omega_c t)$$

Above given signal is NBFM signal.



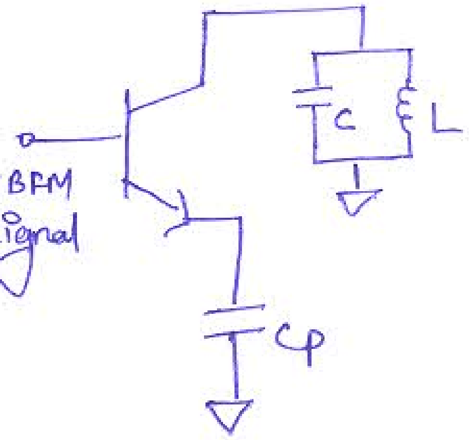
NBFM Generation.

We have employed an integrator to convert PM signal to FM.
For better quality, the frequency deviation must be increased which is very small in case of an NBFM signal.

(b) NBFM-to-WBFM Conversion using Frequency Multiplier :-

$$\cos\theta \longrightarrow \boxed{\times n} \longrightarrow \cos[n\theta]$$

Multiplier is circuit that can be used to increase the Δf of NBFM signal. A practical circuit is as shown in figure. When operated in class C mode, the output collector current contains "spurts" of input signal with all harmonics.



The n^{th} harmonic may be filtered out using band-pass-filter operating at resonant frequency $f_0 = \frac{1}{2\pi\sqrt{LC}} = nf_i$

Section C

11. Describe PCM TDM for T1 carrier system with required block diagram. Explain frame formation, if this system is used for telephone switching system.

Ans.

Fig:- T1 Carrier transmission Scheme

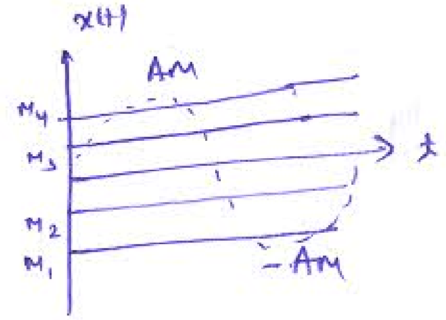
A commutator rotating at f_s samples/sec is used to take out samples from each of n- signals (baseband) one-by-one. Samples collected are transmitted after quantization and encoding through the communication channel. At receiver end, de-commutator, is in perfect synchronization with the speed of commutator. Reconstruction of samples may only be done when sampling satisfies Nyquist criteria.

Frame Structure:-

- 24- voice signals are samples at a rate 8000 samples/second.
- One complete frame contains 24 voice signal samples.
- Frame duration becomes $\frac{1}{f_s} = 125\ \mu s$.
- Each sample is encoded into 8-bits.
- The first bit of each frame contains information about synchronization.
- Every sixth frame, a signalling bit is transmitted.
- Signalling data are anything but payload data and are generally transmitted for dialling tone, engage tone, ringing tone etc information.
- All the synchronization bits are concatenated to make a sequence which provides information about sync-disruption when a mismatch with stored sequence is made.

12. Prove that SQNR value of normalized input to uniform quantizer is given by $[SQNR]_{dB} = 4.8 + 6n$, where 'n' is number of bits per symbol. A sinusoidal message signal of peak voltage 25 V and having frequency of 5 KHz is transmitted through 256 level PCM system. Sampling rate is 30% higher than Nyquist rate. Find R_b, T_b, f_s, n, BW, Δ.

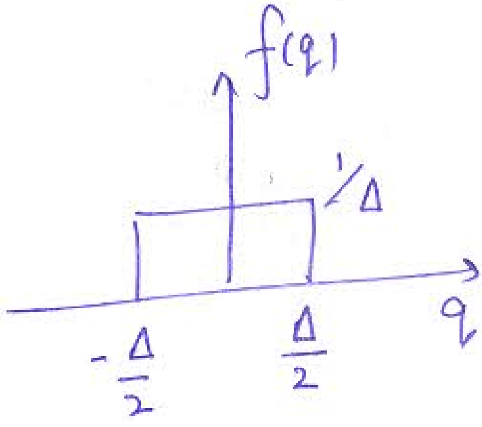
Ans. For uniform quantization,



Number of levels

$M = 2^n$

$n \triangleq$ Number of bits



Considering uniformly distributed noise, quantization noise power

$$\sigma_q^2 = \int_{-\infty}^{+\infty} q^2 f(q)\, dq$$

$$= \int_{-\frac{\Delta}{2}}^{\frac{\Delta}{2}} q^2 \times \frac{1}{\Delta}\, dq$$

$$\sigma_q^2 = \frac{\Delta^2}{12}$$

signal power $= \frac{A_m^2}{2}$

signal-to-quantization Noise Ratio

$$SQNR = \frac{A_m^2/2}{\Delta^2/12}$$

But Δ = step size

$$= \frac{2A_m}{M}$$

$$\therefore SQNR = \frac{3}{2} M^2 = \frac{3}{2} 2^{2n}$$

$$[SQNR] = 4.8 + 6.02n$$

Numerical

$A_m = 25V$

$M = 256$ Levels

$f_s = 30\%$ of f_q

$f_q = 2f_m = 2 \times 5 = 10k$ samples/sec

$f_s = 10k + \frac{30}{100} \times 10k = 13k$ samples/sec.

$M = 256 = 2^n$

$n = \log_2 256 = 8$ bits

$n = 8$ bits.

R_b Bit Rate $= n f_s$

$$R_b = 104 \text{ kbps}$$

Bandwidth: $BW = \frac{R_b}{2} = 52 \text{ KHz}$

n = number of bits = 8 bits

T_b is bit duration

$$T_b = \frac{1}{R_b} = 9.61 \ \mu sec$$

Step-size $\Delta = \frac{2 A_m}{M} = \frac{2 \times 25}{256}$

$$\Delta = 195.31 \text{ mV}$$

mes