Numerical

- A television Signal with a bandwidth of 4.2 MHz is transmitted using a binary PCM and the number of quantization levels is 512.Calculate?

a) Codeword Length

b) Transmission Bandwidth

c) Final Bit rate

d) Output Signal to Quantization Noise Ratio

Numerical

Solution

- Codeword Length:

$$L = 2^R$$

$$512 = 2^R$$

$$\text{Log}_{10}512 = \text{Log}_{10}2^R = \text{Rlog}_{10}2$$

$$\frac{2.709}{0.3010} = R$$

R = 9 bits

Numerical

- Transmission BW:(B_T) $B_T \geq R * W$

$$B_T \geq 9 \times 4.2\ MHz$$

$$\boldsymbol{B_T = 37.8\ MHz}$$

- Final Bit Rate:(r) $r = R \times f_s = 9 \times 2W$

$$r = 9 \times 2 \times 4.2MHz$$

$$\boldsymbol{r = 75.6\ Mbps}$$

- Output Signal to Quantization Noise Ratio

$$(SNR)_{dB} = 4.8 + 6R \rightarrow 4.8 + 6(9)$$

$$\boldsymbol{(SNR)_{dB} = 58.8dB}$$

Numerical

- The information in an analog signal voltage wave form is to be transmitted over a PCM system with an accuracy of $\pm$ 0.1%. The analog voltage waveform has a bandwidth of 100 Hz and an amplitude range of - 10 to + 10V.
- (i) Determine the maximum sampling rate required.
- (ii) Determine the number of bits in each PCM word.
- (iii) Determine minimum bit rate required in the PCM signal.
- (iv) Determine the minimum absolute channel bandwidth required for the transmission of the PCM signal.

Numerical

Solution

- Given accuracy = $\pm$ 0.1%.
- BW= 2W = 100Hz
- Xmax = Amplitude range = -10 to + 10V.
- **Maximum Sampling Rate:**

$$f_s \geq 2W \; or = 2W = 2 \times 100 = 200Hz$$

- **No.of bits in PCM:**

$$\frac{\Delta}{2} = 0.1\% = 0.001$$

$$\Delta = 0.002$$

Numerical

$$\Delta = \frac{2V_p}{L} \rightarrow L = \frac{2(10)}{0.002}$$

$$L = 10000; L = 2^R \rightarrow R = 13.289 \cong 13$$

- Minimum Bit rate:

$$r = R \times f_s = \mathbf{13 \times 200 = 2600} \boldsymbol{bps}$$

- Minimum Absolute Channel BW:

$$B_T = \frac{1}{2} r = \frac{1}{2}(2600) = \mathbf{1300} \boldsymbol{Hz}$$

Numerical

- A PCM system uses an uniform quantizer followed by a 7 bit binary encoder. The rate of the system is required to be equal to 50×10^6 bits/sec

a) What is the maximum message BW required for the satisfactory operation of the system

b) Determine the output signal to noise ratio when a full load sinusoidal modulating wave of frequency 1 MHz is applied to the input.

Numerical

Solution:

$$R = 7 \text{ bits}$$

$$r = 50 \times 10^6 \text{bits/sec}$$

- Maximum Message BW:

$$B_T = \frac{1}{2} r$$

$$= \frac{1}{2} \times 50 \times 10^6$$

$$\boxed{B_T = 25 \text{ MHz}}$$

$$B_T \geq W.R$$

$$\frac{B_T}{R} = W$$

$$\boxed{W = 3.57 \text{ MHz}}$$

SNR(dB) = 1.8 + 6R
= 43.8 dB

Numerical

- The bandwidth of a television video plus audio is 4.5 MHz. If the signal is converted to PCM bits stream with 1024 quantization levels
- Determine the number of bits/sec generated by the PCM system. Assume that the signal is sampled at the rate of 20% above the Nyquist rate.

Numerical

- The bandwidth of a television video plus audio is 4.5 MHz. If the signal is converted to PCM bits stream with 1024 quantization levels
- Determine the number of bits/sec generated by the PCM system. Assume that the signal is sampled at the rate of 20% above the Nyquist rate.
- **Solution:**

$$\text{Band Width} = W = 4.5 \text{ MHz}$$

$$L = 1024$$

$$L = 2^R$$

$$1024 = 2^R$$

$$\log_{10} 1024 = R \cdot \log_{10} 2$$

$$\boxed{R = 10 \text{ bits}}$$

Numerical

$$\text{Nyquist Rate} \geq 2W \geq 9\ \text{MHz}$$

$$r = R \times f_s = R \times 2W$$

$$r = 10 \times 2\ (4.5\ \text{MHz})$$

$$\boxed{r = 90\ \text{Mbits/sec}}$$

- Signal is sampled 20% above Nyquist Rate

$$\therefore f_s = 1.2 \times 2W \qquad (\text{since } 20\% \Rightarrow 1 + 0.2 = 1.2]$$

$$f_s = 10.8\ \text{MHz}$$

$$r = R \times f_s$$

$$= \Rightarrow 10 \times 10.8\ \text{MHz}$$

$$\boxed{r = 108\ \text{Mbits/sec}}$$

Numerical

- A signal of bandwidth 3.5 KHz is sampled, Quantized and coded by a PCM. The coded signal is then transmitted over transmission channel of supporting transmitted range equal to 50Kbits/sec,
- Calculate the maximum signal to noise ratio that can be obtained by this system. The input signal has a peak to peak value of 4 volts and rms value of 0.2 volts.

Numerical

- Solution:

$$W = 3.5\ \text{KHz},\ r = 50 \times 10^3\ \text{bits/sec}$$

$$V_{max} = 2R,\ V_{rms} = 0.2$$

$$P = \frac{V_{rms}^2}{R} \qquad (\because R = 1)$$

$$P = \frac{(0.2)^2}{1}$$

$$\boxed{P = 0.04\ \text{W}}$$

$$SNR = \frac{3P\,(2^{2R})}{V_p^2}$$

$$r = R \times f_s$$

$$R = \frac{r}{f_s} \qquad \{\because f_s = 2W\}$$

$$R = \frac{50 \times 10^3}{2 \times 3.5 \times 10^3} = 7.142$$

$$\boxed{R = 8\ \text{bits}}$$

$$SNR = \frac{3 \times 0.04 \times 2^{16}}{4} = 1966.08$$

$$\boxed{SNR = 1966.08}$$

$$(SNR)_{dB} = 10 \log_{10} 1966.08$$

$$(SNR)_{dB} = 33\ dB$$

Numerical

- The Bandwidth of the signal input to the PCM is restricted to 4 KHz
- The input varies from -3.8 to + 3.8 V and has an average power of 30 mW and the required signal to noise ratio is 20 dB, the modulator produces a binary output.
- Assume uniform Quantization and calculate the number of bits required per sample.
- Outputs of 30 such PCM coders are time multiplexed What is the minimum required transmission Bandwidth for the multiplexed signal.

Numerical

- Solution:

Given, $W = 4$ KHz

$V_p = 3.8\ V$

$P = 30$ mW

$(SNR)_{dB} = 20$ dB

$R = ?$

$(SNR)_{dB} = 20$ dB

$R = ?$

$$(S/N)_{dB} = 10 \log_{10}(S/N)$$

$$= \text{Antilog}\left(\frac{20}{10}\right)$$

$$\boxed{S/N = 100}$$

Numerical

$$\frac{S}{N} = \frac{3P \times 2^{2R}}{V_p^2}$$

$$100 = \frac{3 \times 30 \text{ mw} \times 2^{2 \times R}}{(3.8)^2}$$

$$\boxed{R = 7 \text{ bits}}$$

- Multiplexing 30 PCM

$$B_T \geq RW$$

$$B_T = 30 \times R \times 4 \text{ KHz}$$

$$\boxed{B_T = 840 \text{ KHz}}$$

Numerical

- A signal $x(t) = 5\cos(1000\pi t)$ is sampled and quantized using 8 bit PCM system. Find the signal to quantization noise ratio.
- **Solution:**

- A sinusoidal signal is transmitted using PCM. An Output SNR of 55.8 dB is required. Find the number of Levels to achieve this.
- **Solution:**

Numerical

- A signal $x(t) = 5\cos(1000\pi t)$ is sampled and quantized using 8 bit PCM system. Find the signal to quantization noise ratio.
- **Solution:**

$$(SNR)_{dB} = 1.8 + 6R \rightarrow 1.8 + 6(8) = 1.8 + 48 = \mathbf{49.8dB}$$

- A sinusoidal signal is transmitted using PCM. An Output SNR of 55.8 dB is required. Find the number of Levels to achieve this.
- **Solution:**

$$(SNR)_{dB} = 1.8 + 6R \rightarrow 55.8 = 1.8 + 6R \rightarrow 6R = 54 \rightarrow R = 9$$

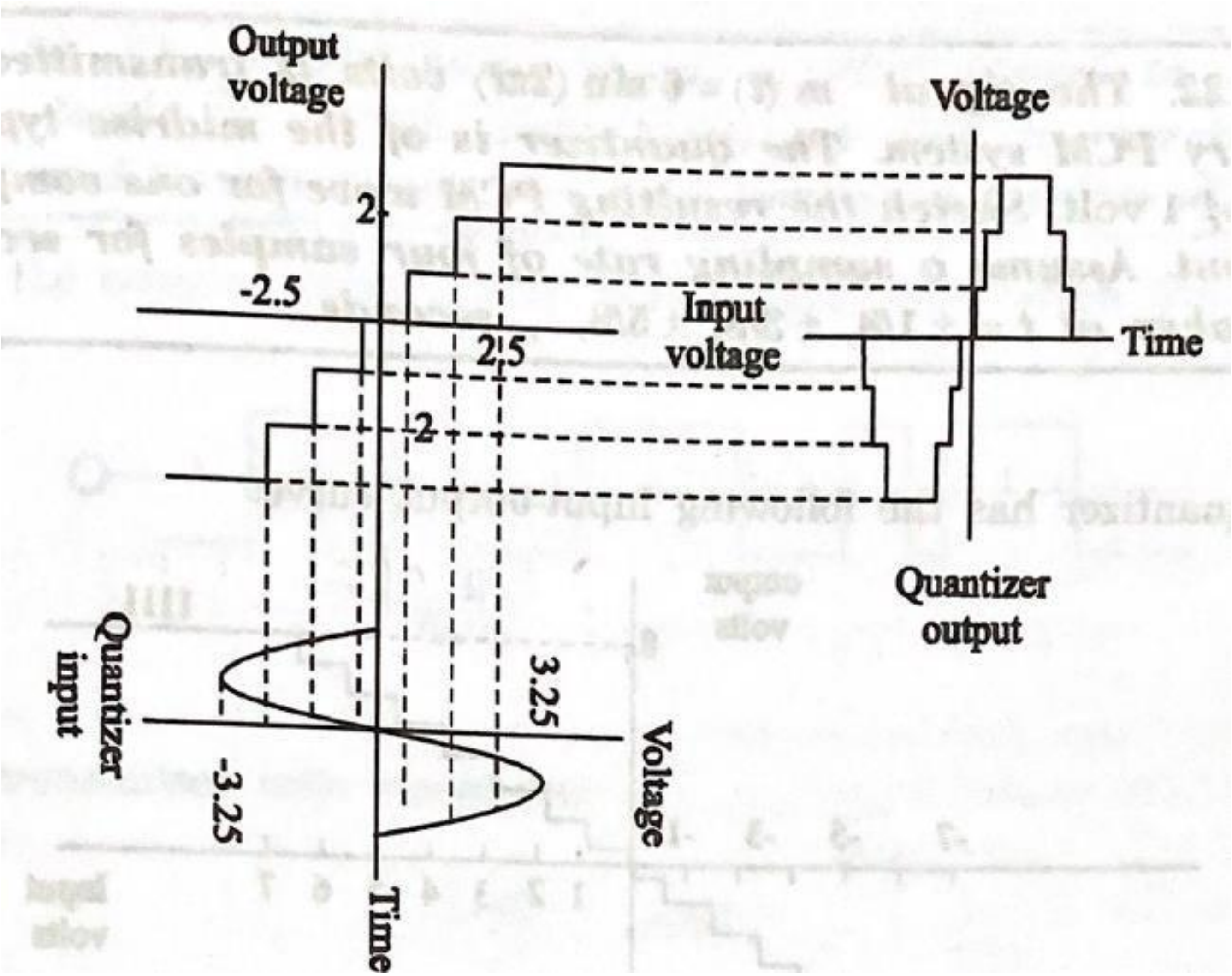
$$L = 2^R = 2^9 = \mathbf{512\ Levels}$$

Numerical

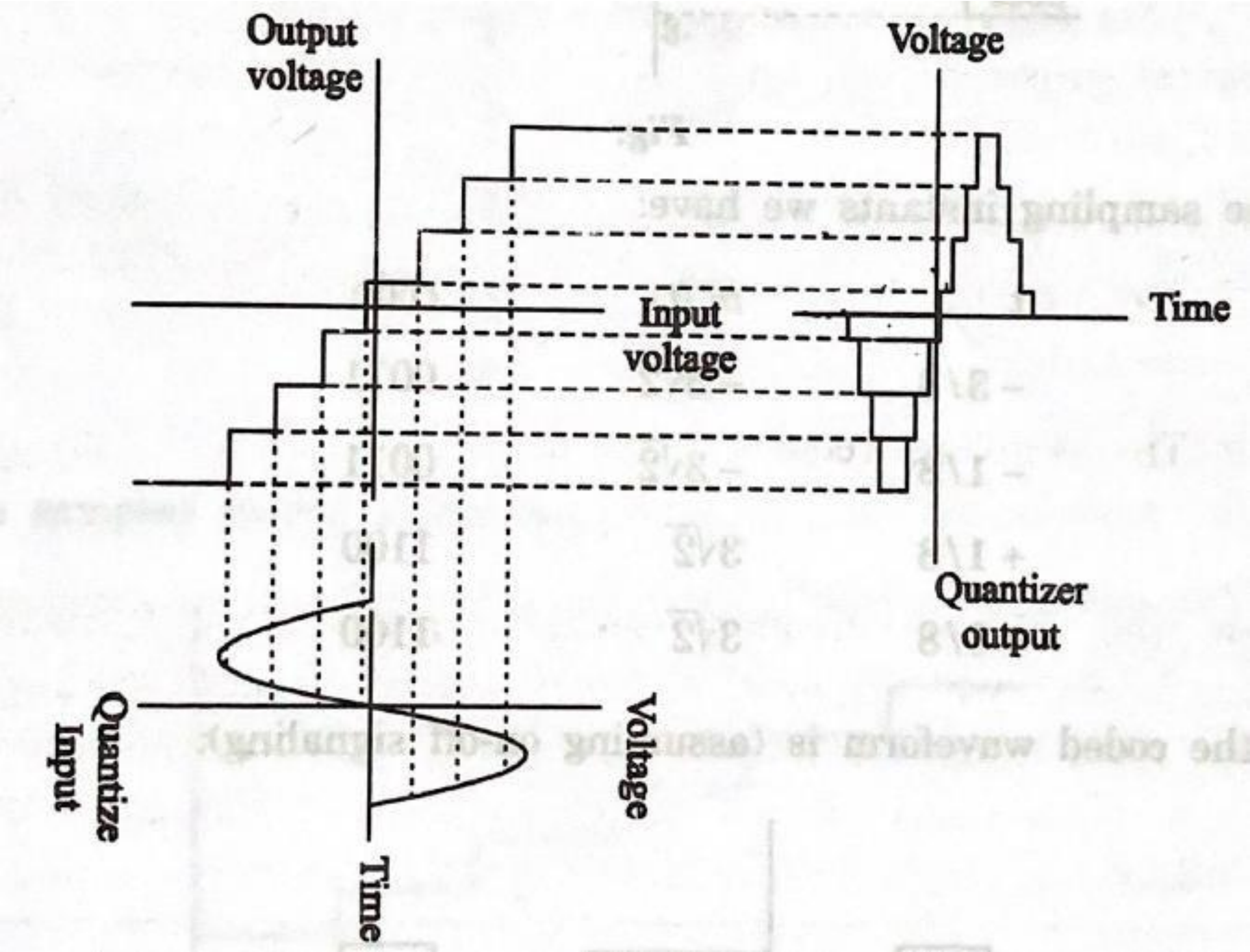
- A sinusoidal signal, with an amplitude of 3.25 volts is applied to a uniform quantizer of the mid-tread type
- whose output takes on the values 0, $\pm$1, $\pm$ 2, $\pm$ 3 volts. Sketch the waveform of the resulting quantizer output for one complete cycle of the input.
- Repeat the evaluation for the case when the quantizer is of the midrise type whose output takes on the values= 0.5, $\pm$ 1.5, $\pm$ 2.5, $\pm$ 3,5volts.

Numerical

- Solution:



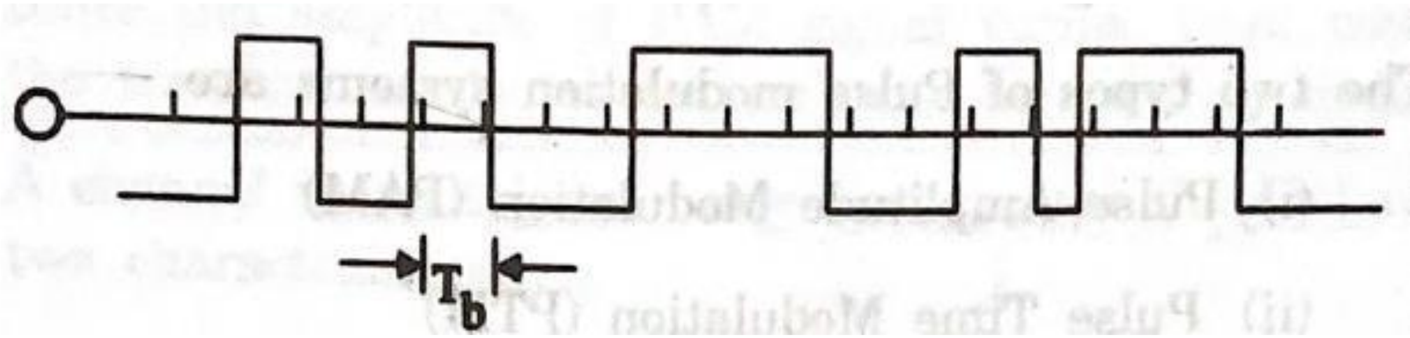
Numerical



Output voltage
Voltage
Input voltage
Time
Quantizer output
Quantize Input
Voltage
Time

Numerical

- The figure below shows a PCM signal in which the amplitude levels of +1 Volt and -1 Volt are used to represent binary symbols 1 and 0.The codeword used have 3 bits.



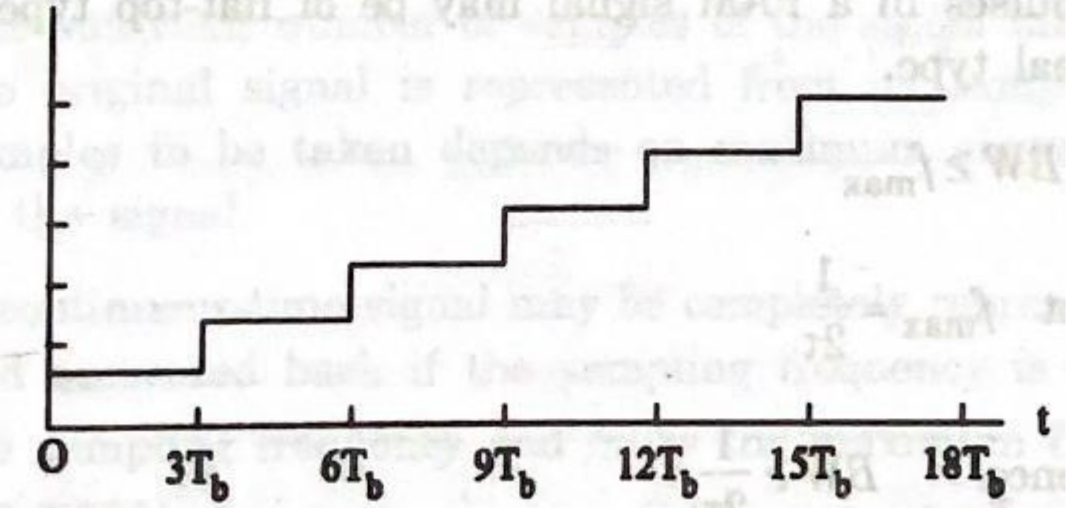
- Find the sampled version of an analog signal from which the above PCM signal is derived.

Numerical

- The transmitted codes are

t/T_b	code
1	001
2	010
3	011
4	100
5	101
6	110

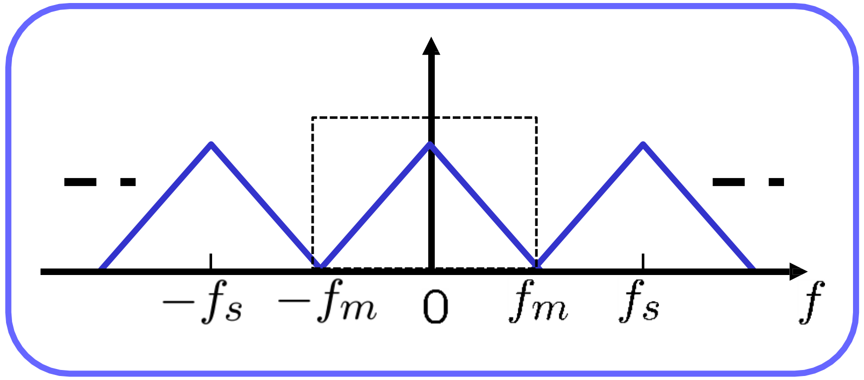
- The samples analog signal



Numerical

- Let $x(t) = \cos(10\pi t) + \cos(30\pi t)$ be sampled at 20Hz and reconstructed using an ideal low pass filter with cut off frequency of 20Hz. Then compute the frequencies present in the reconstructed signal.

$$G_\delta(f) = f_s \sum_{n=-\infty}^{\infty} G(f - nf_s)$$



Numerical

- Let $x(t) = \sin(400\pi t)$ be sampled at 300Hz and reconstructed using an ideal low pass filter with cut off frequency of 150Hz. Then compute the frequencies present in the reconstructed signal.

Numerical

- Convert the analog signal to digital format using following data

1. Sinusoidal signal frequency = 4KHz
2. $f_s = 5f_m$
3. Levels of Quantization = 4