Comm. Engg. KEC-401 PUT

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Section-B

Question 12.

In single tone amplitude modulation,

$$S_{AM}(t) = A_c\{1 + K_a m(t)\}\cos 2\pi f_c t$$

Let $m(t) = A_m \cos 2\pi f_m t$

$$\Rightarrow S_{AM}(t) = A_c\{1 + K_a A_m \cos 2\pi f_m t\}\cos 2\pi f_c t$$

where $K_a A_m = \mu$
(mod^n Index)

$$\Rightarrow S_{AM}(t) = A_c\{1 + \mu \cos 2\pi f_m t\}\cos 2\pi f_c t$$

$$= A_c \cos 2\pi f_c t + A_c \mu \cos 2\pi f_c t \cdot \cos 2\pi f_m t$$

$$= \underbrace{A_c \cos 2\pi f_c t}_{\text{Carrier}} + \frac{A_c \mu}{2}\{\underbrace{\cos 2\pi (f_c + f_m)t}_{\text{USB}} + \underbrace{\cos 2\pi (f_c - f_m)t}_{\text{LSB}}\}$$

Kavish

~~Total~~

Total Power, $P_t = P_c + P_{USB} + P_{LSB}$

$$P_c = \frac{A_c^2}{2R} \; ; \; P_{USB} = \frac{\left(\frac{A_c\mu}{2}\right)^2}{2R} = P_{LSB}$$

$$= \frac{A_c^2\mu^2}{8R}$$

$$\Rightarrow P_t = \frac{A_c^2}{2R} + \frac{A_c^2\mu^2}{8R} + \frac{A_c^2\mu^2}{8K}$$

$$= \frac{A_c^2}{2R}\left[1 + \frac{\mu^2}{2}\right]$$

$$\boxed{P_t = P_c\left\{1 + \frac{\mu^2}{2}\right\}}$$

$$\boxed{P_{SB} = \frac{A_c^2\mu^2}{4R} = \frac{P_c\mu^2}{2}}$$

Efficiency, $\eta = \frac{P_{SB}}{P_t} \times 100 = \frac{1 + \frac{\mu^2}{2}}{\frac{\mu^2}{2}} \times 100$

$$= \frac{\mu^2 + 2}{\mu^2} \times 100\%$$

Question 13.

Mathematical Exp. of FM Signal

Carrier signal before modulation ⇒

$$c(t) = A_c \cos\{2\pi f_c t + \phi\}$$

$$= A_c \cos\{\theta(t)\}$$

Where $\theta(t) = 2\pi f_c t + \phi$ —— (1)

Diff. wrt t (1)

$$\boxed{\frac{d\theta(t)}{dt} = 2\pi f_c}$$

For instantaneous frequency, f_i

$$\theta(t) = \theta_i(t)$$

$$\Rightarrow \quad \frac{d\theta_i(t)}{dt} = 2\pi f_i$$

or $$\boxed{f_i = \frac{1}{2\pi}\frac{d\theta_i(t)}{dt}}$$ —— (2)

We know, $S_{FM}(t) = A_c \cos \theta_i(t)$ —— (3)

From eq (2), $\theta_i(t) = 2\pi \int [f_i dt]$

$$= 2\pi \int \{f_c + K_f m(t)\} dt$$

Kanish

$$= 2\pi f_c t + 2\pi K_f \int_{-\infty}^{t} m(t)\,dt$$

or $$2\pi f_c t + 2\pi k_f \int_{0}^{t} m(t)\,dt \quad \text{--- (4)}$$

From eq (3), (4),

$$S_{FM}(t) = A_c \cos\left\{ 2\pi f_c t + 2\pi K_f \int_0^t m(t)\,dt \right\}$$

$\Rightarrow$ let $m(t) = A_m \cos 2\pi f_m t$

$$S_{FM}(t) = A_c \cos\left\{ 2\pi f_c t + \cancel{2\pi} K_f \cdot \frac{A_m \sin 2\pi f_m t}{\cancel{2\pi} f_m} \right\}$$

where $\frac{K_f A_m}{f_m} = \beta$ (Modn Index)

Therefore, $\boxed{S_{FM}(t) = A_c \cos\{ 2\pi f_c t + \beta \sin 2\pi f_m t \}}$

Kamlesh

Question 11.

We know, $P_t = P_c\left(1 + \frac{\mu^2}{2}\right)$ —— (1)

Since $P \propto I^2$,

eq (1) can be written as,

$$I_t^2 = I_c^2\left(1 + \frac{\mu^2}{2}\right)$$

or $\boxed{I_t = I_c\sqrt{1 + \frac{\mu^2}{2}}}$ —— (2)

For 1st wave

$I_t = 11\,A$

$\mu = 0.4$

$\therefore$ $\cancel{I_t} \rightarrow 11 = I_c\sqrt{1 + \frac{0.16}{2}}$

$= I_c \times 1.039$

$\Rightarrow \boxed{I_c = 10.58\,A}$

For 2nd wave

$I_t = 12\,A$

$$I_t = I_c\sqrt{1 + \frac{\mu_1^2 + \mu_2^2}{2}}$$

$$12 = 10.58\sqrt{1 + \frac{(0.16 + \mu_2^2)}{2}}$$

Karishma

$$1.285 = 1 + \left(\frac{0.16 + \mu_2^2}{2}\right)$$

$$\Rightarrow \boxed{\mu_2 = 0.641} \quad \underline{\text{Ans}}$$

Section – C

Question 16. – b) Part

Delta Modulation (DM) is a DPCM scheme in which the difference signal $\Delta(t)$ is encoded into just a single bit. The singal bit used to increase or decrease the estimate $\hat{m}(t)$. This scheme is called linear delta modulation and is shown in Fig. 1.

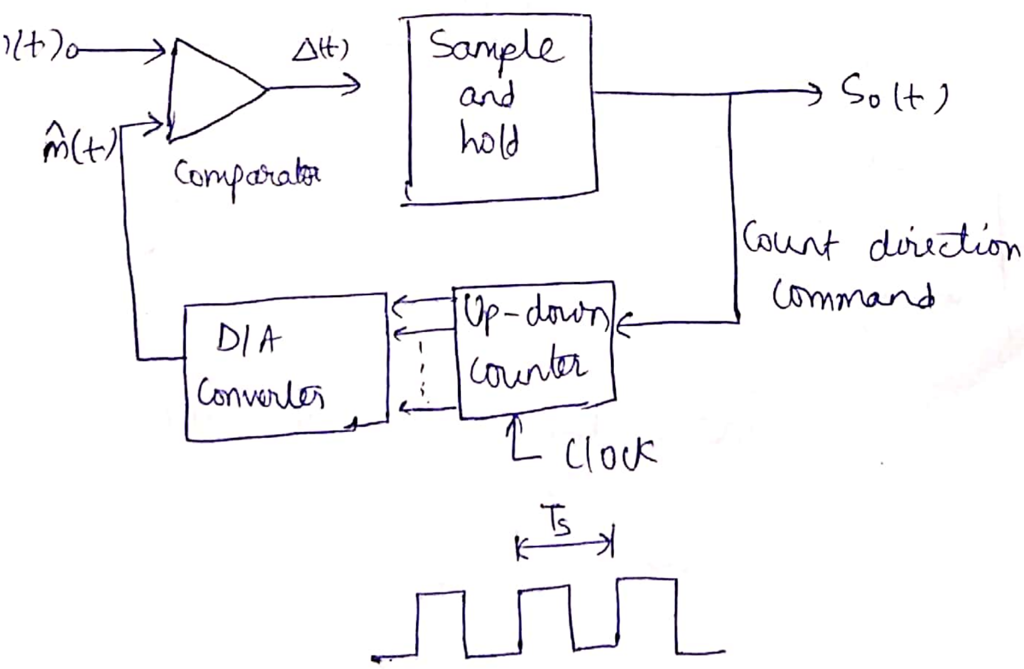


Fig. 1 Delta Modulator

Karina

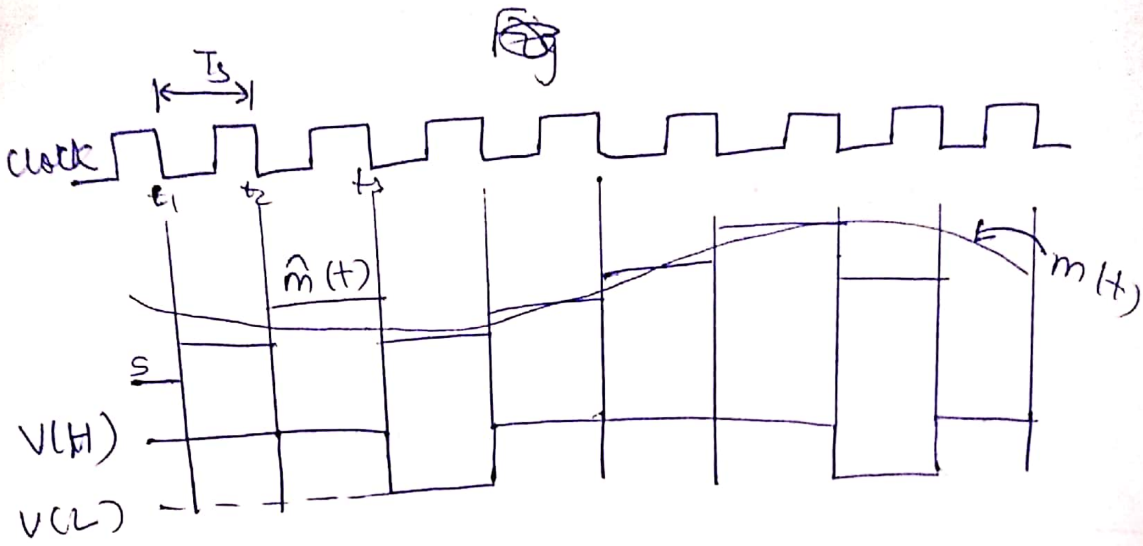


Fig 2. The responce of a delta modulator to a baseband signal m(t).

Error in DM

1. Slope overload distortion

From fig3, due to small step size (Δ), the slope of the approximated signal $x'(t)$ will be small.

The slope of $x'(t) = \frac{\Delta}{T_s} = \Delta f_s$

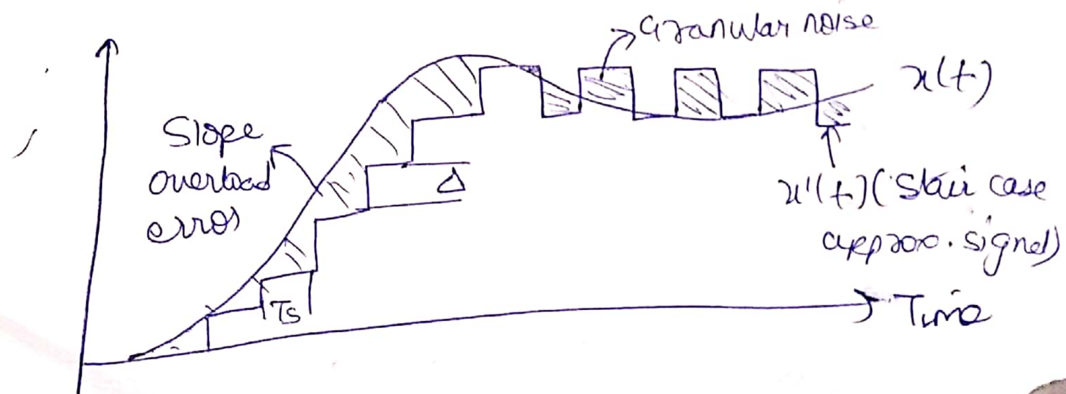


Fig 3. Distortion In DM

If ~~#~~ slope of $x(t) >> x'(t)$ over a long duration then $x'(t)$ will not be able to follow $x(t)$ at all. The difference between $x(t)$ & $x'(t)$ is called as Slope overload distortion.

Thus the slope overload error occurs when slope of $x(t)$ is much larger that slope of $x'(t)$.

2. Granular Noise – when the $x(t)$ is relatively constant in amplitude, the $x'(t)$ will hunt above and below $x(t)$ as shown in fig 3. It increases with increase in Δ.

A system with a variable step size is known as the adaptive delta modulator. (ADM).

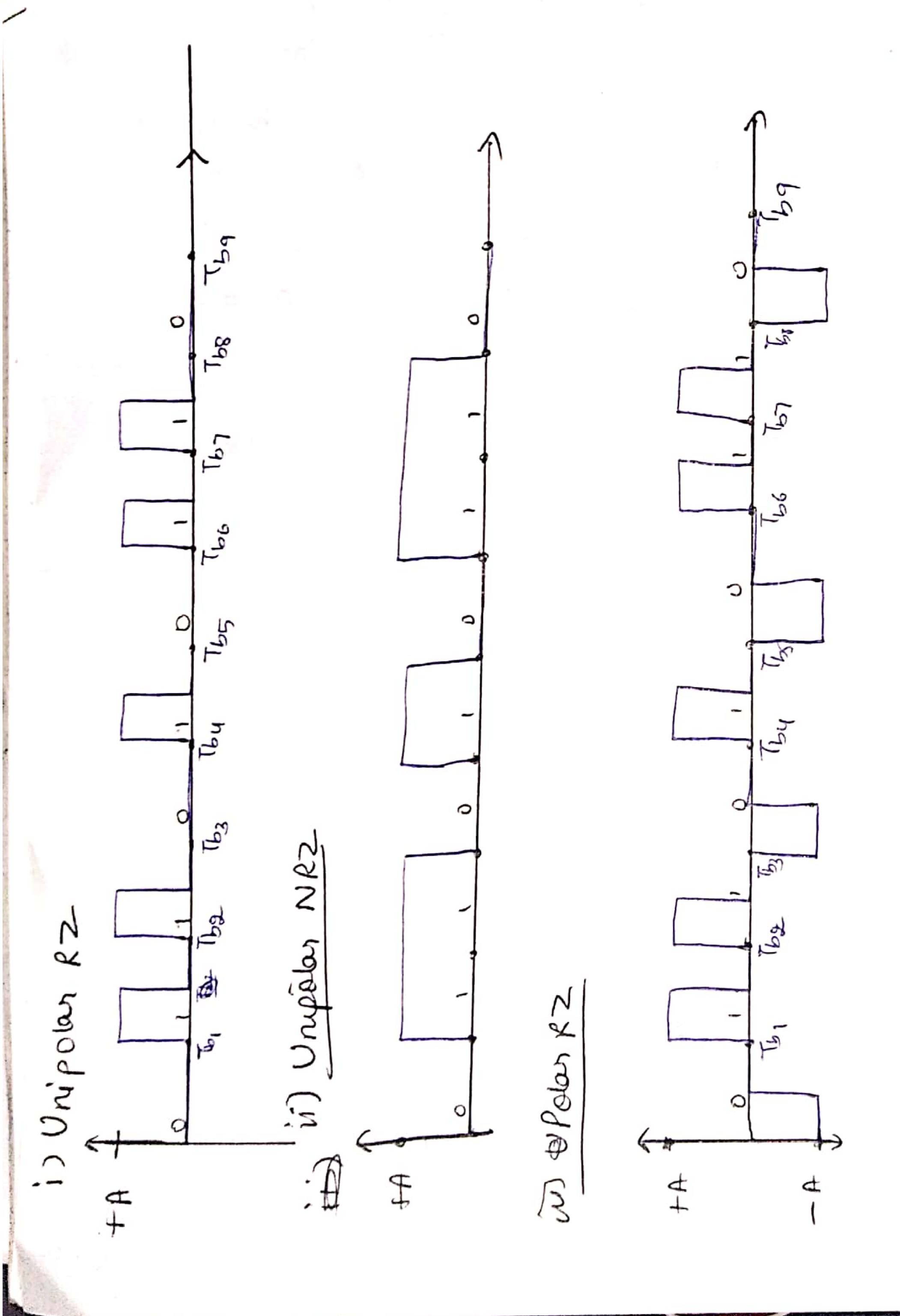
∴ This Granular Noise can be overcome in ADM.

Kaiser

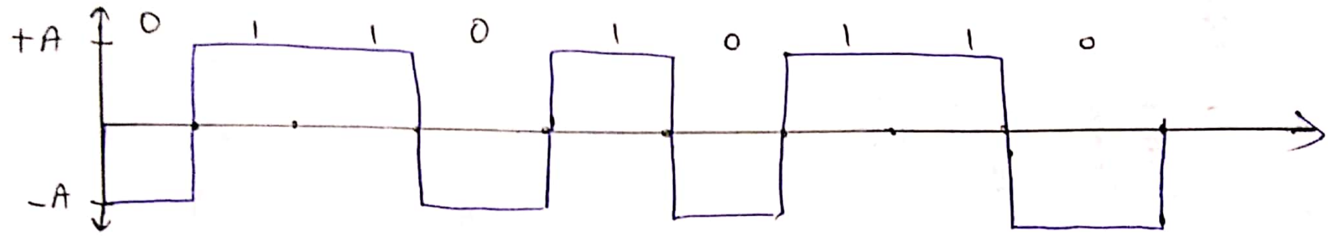
Question18.

a) Part

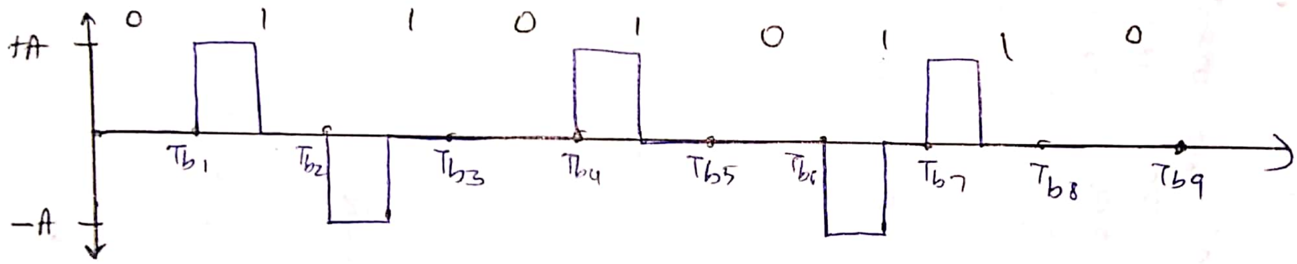
Given seq. 011010110



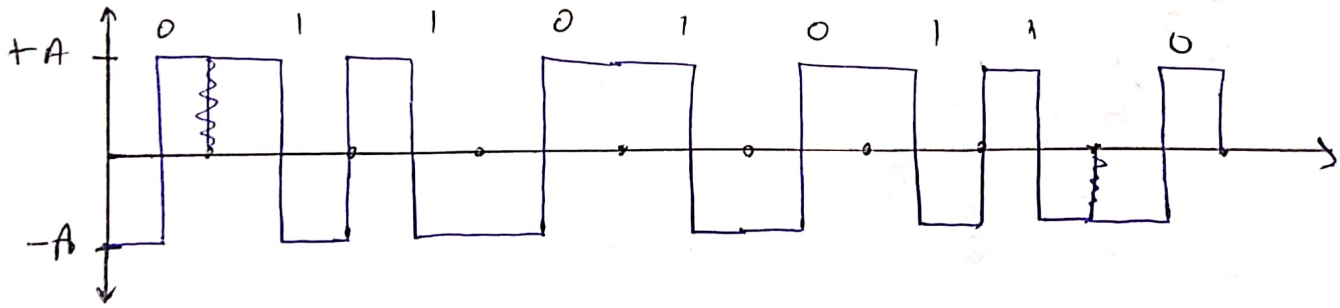
iv) Polar NRZ



v) AMI



vi) Manchester



Question 17.

b) Part.

Quantization Error

For uniform quantization or linear quantization, inherent errors are introduced in the signal this error is called as Quantization error.

It is given as,

$$\varepsilon = x_q(nT_s) - x(nT_s)$$

Let us assume that the input $x(nT_s)$ to a linear or uniform quantizer has continuous amplitude in range $-x_{max}$ to $+x_{max}$.

So total amplitude range $= 2x_{max}$.

~~and or dis~~

$$\text{Step size } \Delta = \frac{\text{Max amplitude range}}{\text{No. of levels}}$$

$$= \frac{2x_{max}}{q}$$

For normalised input,

$$\Delta = \frac{2}{q} \quad \text{or} \quad x_{max} = 1, \; -x_{max} = -1$$

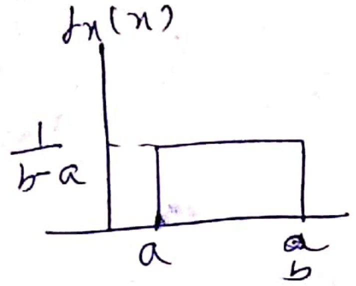
and max quan^n error

$$\varepsilon_{max} = \left|\frac{\Delta}{2}\right| =$$

i.e. $-\frac{\Delta}{2} \leq \varepsilon_{max} \leq \frac{\Delta}{2}$

Karan

This quantization error may be assumed as an uniformly distributed random variable over the interval $\left(-\frac{\Delta}{2}, \frac{\Delta}{2}\right)$ as shown below,

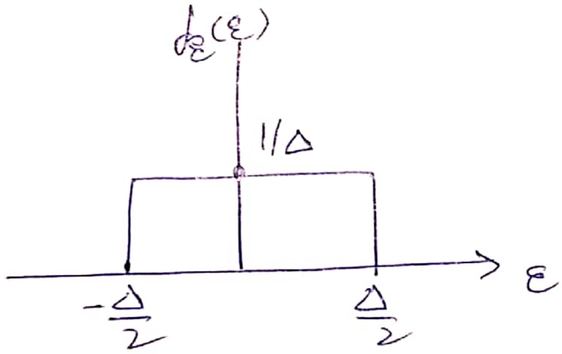


For this, Power density function is expressed as

$$f_X(x) = \begin{cases} 0 & ; \; x \leq a \\ \frac{1}{b-a} & ; \; a < x \leq b \\ 0 & ; \; x > b \end{cases}$$

Similarly for ε_{max},

$$f_\varepsilon(\varepsilon) = \begin{cases} 0 & ; \; \varepsilon \leq \frac{\Delta}{2} \\ \frac{1}{\Delta} & ; \; -\frac{\Delta}{2} < \varepsilon \leq \frac{\Delta}{2} \\ 0 & ; \; \varepsilon > \frac{\Delta}{2} \end{cases}$$



So noise power for quantization noise

$$= \frac{V_{noise}^{2}}{R} \; *$$

* where V_{noise}^{2} is Mean Square Value

$$E[\varepsilon^2] = \overline{\varepsilon^2} = \int_{-\infty}^{\infty} \varepsilon^2 f_\varepsilon(\varepsilon)\, d\varepsilon$$

$$E(\varepsilon^2) = \int_{-\Delta/2}^{\Delta/2} \varepsilon^2 f_\varepsilon(\varepsilon)\, d\varepsilon$$

$$= \int_{-\Delta/2}^{\Delta/2} \varepsilon^2 \times \frac{1}{\Delta}\, d\varepsilon = \frac{1}{\Delta}\left[\frac{\varepsilon^3}{3}\right]_{-\Delta/2}^{\Delta/2}$$

$$= \frac{1}{\Delta} \times \frac{\Delta^3}{3\times 4} = \frac{\Delta^2}{12}$$

$$\boxed{E(\varepsilon^2) = \frac{\Delta^2}{12}}$$

This is normalised quantization noise power when $R = 1$

Now let peak to peak voltage is $-m_p$ to m_p, is total number of quantizing level as L then,

$$\Delta = \frac{2m_p}{L}$$

$$\langle q_e^2 \rangle = \frac{4m_p^2}{L^2 \times 12}$$

$$\boxed{q_e^2 = \frac{m_p^2}{3L^2}}$$

If the encoder used for decimal to binary conversion have n bits, then $L = 2^n$

$\Rightarrow$ Quantization Error $\langle q_e^2 \rangle = \dfrac{m_p^2}{3 \cdot 2^{2n}}$

Ravish

~~SNR~~ SQNR

Signal to Quantize Noise Ratio $= \dfrac{\text{Normalised Signal Power}}{\text{Normalised quantize noise power}}$

Signal power: $P = \dfrac{m_p^2}{2}$

Quantized noise power, $Q_e = \dfrac{m_p^2}{3L^2}$

~~SQ~~ SQNR $= \dfrac{\frac{m_p^2}{2}}{\frac{m_p^2}{3L^2}} = \boxed{\dfrac{3L^2}{2}}$

$$\text{SQNR (dB)} = 10 \log_{10} \frac{3L^2}{2}$$

$$= 20 \log_{10} \frac{3 \cdot 2^{2n}}{2}$$

$$= 1.76 + 6.02n$$

$$\boxed{\text{SQNR} \simeq 1.8 + 6n}$$