① Find the minimum sampling frequency $f_s(min)$ to avoid slope overload, when $x(t) = \cos(2\pi 800t)$ and step size $\Delta = 0.1$.

Solution

$\Delta = 0.1$

$x(t) = \cos(2\pi 800t)$

To avoid slope overload

$$A_m \leq \frac{\delta f_s}{2\pi f_m} \qquad \boxed{f_m = 800}$$

$$f_s \geq \frac{2\pi f_m A_m}{\delta}$$

$$f_s \geq \frac{2\pi \times 800 \times 1}{0.1}$$

$$\boxed{f_s \geq 16000\pi}$$

Nyquist rate $f_s = 2f_m$

$= 2 \times 800$

$= 1600$ Hz

Sampling frequency is 10π times of Nyquist rate.

② Where $x(t) = 6\sin(2\pi \times 10^3 t) + 4\sin(4\pi \times 10^3 t)$. Determine the minimum sampling rate that will prevent slope overload, if the step size is 0.314 Volt.

Solution

$$x(t) = 6 \sin(2\pi \times 10^3 t) + 4 \sin(4\pi \times 10^3 t) \text{ volt}$$

$$\Delta = 0.314$$

To avoid slope overload

$$\delta / T_s \geq \max \left| \frac{d\,x(t)}{dt} \right|$$

$$L.H.S = \delta / T_s = \delta f_s = 0.314 f_s$$

$$R.H.S = \max \left| \frac{d\,x(t)}{dt} \right|$$

$$= \frac{d}{dt} \left| 6 \sin(2\pi \times 10^3 t) + 4 \sin(4\pi \times 10^3 t) \right|$$

$$= \left| 6 \times (2\pi \times 10^3) \cos(2\pi \times 10^3 t) + 4(4\pi \times 10^3) \cos(4\pi \times 10^3 t) \right|_{max}$$

$$= (t = 0 \quad \cos 0 = 1)$$

$$= 12\pi \times 10^3 + 16\pi \times 10^3$$

$$= 28\pi \times 10^3$$

$$L.H.S \geq R.H.S$$

$$0.314 f_s \geq 28\pi \times 10^3$$

$$f_s \geq \frac{28\pi \times 10^3}{0.314}$$

$$f_s \geq 280 \times 10^3$$

$$\boxed{f_s \geq 280 \text{ kHz}}$$

(3) The input to a Delta modulator is a Sinusoidal signal whose frequency can vary from 200 Hz to 4000 Hz. The input is Sampled at eight times the Nyquist rate. The peak amplitude of the Sinusoidal Signal is 1V.

a) Determine Step Size in order to avoid Slope overload when the input Signal frequency is 800 Hz.

b) Is the modulator overload when the input Signal frequency is 4KHZ.

c) Find peak amplitude, when i/p S/g is frequency is 4KH- 200 HZ, when overload occurs.

Solution

$f_m = 200\,Hz$ to $4000\,Hz$

$= 4000$

Nyquist rate $= 2W$

$= 2 \times 4000$

$= 8000\,HZ$

$f_s = 8$ (Nyquist rate) Given in question

$= 8(8000) = 64000\,Hz$

a) $f_m = 800$

$$\delta \geq \frac{2\pi A_m f_m}{f_s}$$

$A_m = 1$ (given in question)

$$= \frac{2\pi \times 1 \times 800}{64000}$$

$$\boxed{\delta = \pi/40}$$

c) ($f_m = 200$ Hz)

$$\delta \leq \frac{2\pi A_m f_m}{f_s}$$

$$A_m > \frac{\delta f_s}{2\pi f_m}$$

$$A_m > \frac{(\pi/40)(64000)}{2\pi \times 200}$$ ($\delta = \pi/40$ find in case (a))

$$A_m > 4V$$

b) $f_m = 4$ KHZ

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

$$= \frac{(\pi/40)\, 64000}{2\pi \times 4 \times 1000}$$

$$A_m = 0.2$$

$A_m = 0.2$ when $f_m = 4$ KHZ it is less than the amplitude with slope overload